New River Gorge National River
Gauley River National Recreation Area
Bluestone National Scenic River
West Virginia

National Park Service
U.S. Department of the Interior

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Water Resources Management Plan

WATER RESOURCES MANAGEMENT PLAN

NEW RIVER GORGE NATIONAL RIVER, GAULEY RIVER NATIONAL RECREATION AREA, BLUESTONE NATIONAL SCENIC RIVER, WEST VIRGINIA

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New River Gorge National River
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LIST OF ABBREVIATIONS AND ACRONYMS

AHR	American Heritage River
AMLR	Abandoned Mine Lands Reclamation (WVDEP)
BLM	Bureau of Land Management (U. S. Department of the Interior)
BLUE	Bluestone National Scenic River
CE	Categorical Exclusion
CEQ	Council on Environmental Quality
COE	United States Army Corps of Engineers
DEP	Division (or Department) of Environmental Protection
DNR	Division (or Department) of Wildlife Resources
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
EO	Executive Order
EPA	U. S. Environmental Protection Agency
et al.	Abbreviation for Latin *et alii*, meaning ‘and other’. Used in author citations within the text when there are more than two authors of a source document.
et seq.	Abbreviation for Latin *et sequentia*, meaning ‘and the following ones’. Usually used in citations of legal documents.
FONSI	Finding of No Significant Impact
FS	Forest Service (U. S. Department of Agriculture)
FWS	United States Fish and Wildlife Service
GARI	Gauley River National Recreation Area
GMP	General Management Plan
LTEMS	Long-Tern Ecological Monitoring System
Mcf	Thousand cubic feet
MOU	Memorandum Of Understanding
NAWQA	National Water Quality Assessment program (USGS)
NEPA	National Environmental Policy Act
NERI	New River Gorge National River
NMFS	National Marine Fisheries Service (U. S. Department of Commerce)
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCP	New River Community Partners

NRCS	Natural Resources Conservation Service (U. S. Department Agriculture; successor to the Soil Conservation Service, or SCS)
NSPA	Natural Streams Preservation Act (WV)
OSM	Office of Surface Mining Reclamation and Enforcement (U. S.)
PAH	Polycyclic Aromatic Hydrocarbon
PAN	Plateau Action Network
PL	Public Law
RMP	Resource Management Plan
RM&VP	Resource Management & Visitor Protection
ROD	Record of Decision
RSU	Resource Stewardship Unit
Stat.	Statute
STORET	STOrage and RETrieval (US EPA's water quality database)
TMDL	Total Maximum Daily Load
U. S.	United States
U.S.C.	United States Code
USDA	Unites States Department of Agriculture
USGS	United States Geological Survey
VA	Veteran's Administration (U. S.)
VA	Virginia
VPI	Virginia Polytechnic Institute and State University
WVDEP	West Virginia Division (or Department) of Environmental Protection
WVDNR	West Virginia Division (or Department) of Natural Resources
WVGES	West Virginia Geological and Economic Survey
WRMP	Water Resource Management Plan
WV	West Virginia

EXECUTIVE SUMMARY

New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River contain some of the most significant water resources and water-based recreational activities in the national park system. These parks encompass 86,270 acres, of which the National Park Service owns nearly 58 percent. The New River Gorge has over one million visitors per year, many of whom come to enjoy some of the best white-water rafting in the eastern United States.

All three parks are within the Kanawha River Basin and the Appalachian Plateaus Physiographic Province. The three parks are in Mississippian and Pennsylvanian sedimentary geologic formations, the latter containing extensive coal deposits. The terrain is an ancient plateau that has been eroded into steep, sharply incised hills and valleys. The climate is continental with four distinct seasons, and the parks annually receive about 40 inches of precipitation.

New River Gorge National River and Gauley River National Recreation Area are both immediately downstream from major dams; Bluestone National Scenic River is unregulated. The Meadow River, a major unregulated tributary of the Gauley River, and many minor tributaries are included in the water resources of the parks.

The New and Gauley Rivers and their tributaries are home to about 90 species of fish. Of these fish, 46 species are native. With the remainder being introduced. Eight fish species live nowhere else in the world. No Federally listed endangered or threatened aquatic species live in these three parks, and wetlands are not an extensive resource in this mountainous area.

The primary purposes of this water resources management plan are to: comprehensively describe the water resources of the three parks, describe in detail the water resource issues facing these three parks; and formulate management actions that address those water resource issues.

This plan addresses 11 selected water resource issues. These issues evolved from a Water Resources Scoping Report published in 1996. Each issue was categorized as high, medium, or low priority at a scoping meeting attended by interested federal, state, and local government agencies in September, 1997. Minor modifications in the priorities assigned to some issues have changed due to information that has become available and events that have transpired since the scoping meeting. To address these issues, a number of recommended actions have been developed. These recommended actions will not resolve all of the water resource issues for the three parks. However, they describe steps that should be taken to help resolve these issues. This plan is intended as a “living” document. As such, the parks can make appropriate revisions to the plan as more information becomes available, issues change or arise, and different or modified actions become necessary.

For the most part, the issues identified in this plan may be considered programmatic. They related to the need for understanding park water resources, the impacts that various activities have on those resources, and the role the parks and their water resources play in the region. Addressing these issues will require expanding baseline knowledge of park water resources, long-term monitoring of those resources, developing a greater understanding of land use activities inside and outside of park boundaries, and interacting with outside entities and individuals. Addressing the issues presented in this plan requires long-term commitment and support. Expending the effort and funds necessary to accomplish the recommended actions will provide the necessary foundation for making well informed, scientifically based, issue-oriented management decisions.

The four high priority issues are sewage pollution, water-quality data collection and management, fishery management, and *Bti* application to remove black flies. The four medium priority issues are silvicultural activities, agricultural and urban runoff, mineral development, and future development. The three low priority issues are impoundments, floodplain management, and hazardous waste spills and waste sites.

Among these issues, water-quality data collection and management is unique, because it is an operational issue within the parks, rather than a land or water use that causes stress in park stream ecosystems or to other natural resources. Four recommended actions address this issue. These are:

Technical Evaluation of Water Quality Monitoring Program
Determine Stream Flow Characteristics of New River Tributary Streams
Develop Long-term Monitoring Program for Gauley River National Recreation Area
Evaluate the Long-term Monitoring Program in New River Gorge National River.

Among the land- and water- use issues, pollution resulting from improper sewage disposal is clearly the greatest concern. Improper sewage disposal, both within and outside park boundaries, results in bacterial contamination of park waters, and may present a health risk to park users and employees. Three recommended actions will help managers and scientists understand the human health risks and effects of bacterial contamination in park waters. These are:

Microbial Reconnaissance of New River Gorge National River
Epidemiological Survey of Recreational Water Users in the New and Gauley Rivers
Determine Animal Sources of Fecal Bacteria in New River Gorge National River Tributaries.

No action is recommended to remediate improper sewage disposal. Although the need is obvious, there is no direct way for the National Park Service to directly solve this problem. Indirectly, however, the National Park Service can act to alleviate this threat. Activities such as educational programs and materials presented at visitor centers and to schools and the media are one way to work toward eliminating improper sewage disposal. Coordination with other agencies, particularly the West Virginia Department of Environmental Protection, since it has enforcement authority over water pollution, is another way. The National Park Service also can seek out, and work with, partners (e.g. National Small Flows Clearinghouse, Canaan Valley Institute, and local watershed groups) that might be able to obtain funding for remediation.

With a professional aquatic ecologist and a staff of technicians, the National Park Service is well equipped to address the fishery management issues. In part due to this in-house expertise, 10 recommended actions address this issue. These are:

Historical Fisheries Data Mining
Inventory Fishes of Gauley River National Recreation Area
Inventory Fishes of Bluestone National Scenic River
Monitor Status and Distribution of Fishes in New River Gorge National River

Determine Impacts of Two Fishery Management Methods on Stream Ecosystems
Determine Diets of Exotic Trout in New River Gorge Tributary Streams
Evaluate Impacts of Exotic Trout on New River Tributary Ecosystems
Inventory Biological Resources of New River Tributaries
Outreach to Anglers on the Effects of Bait-Bucket Fish Introductions
Determine Status and Trends of New River Crayfish Community.

The application of the bacterial insecticide *Bti* to kill black flies is an issue almost as old as New River Gorge National River. Contention over this issue led to a court suit, and then to special congressional action that established the spraying program and the National Park Service's long-term monitoring of the impacts of the spraying. One action recommended under the water-quality data collection and management issue (Evaluate the Long-term Monitoring Program in New River Gorge National River) also addresses this issue. One other recommended action specifically addresses baseline information needed to examine an unexplored potential impact of *Bti* application. This action is:

Determine Status and Trends of New River Mussel Community.

Two recommended actions specifically address one of the medium priority issues. Several actions that address water quality data collection and management also address all medium priority issues via the monitoring of water quality to address land use impacts. The two recommended actions that are presented address the issue of mineral development. These are:

Monitor Effectiveness of Wolf Creek AMD Treatment
Determine Partitioning of Polycyclic Aromatic Hydrocarbons in Streams of the New River Watershed.

The silvicultural issue was originally prioritized as "high" largely due to concerns about possible toxic waste discharges from an oriented strand board plant in the Mount Hope area. This plant is recycling wastes instead of discharging them to area streams, so these concerns have alleviated. Also, the effects of logging are difficult to separate from those of road and other construction activities, surface mining, and other soil-disturbing activities. This makes designing an effective program for monitoring only the effects of logging operations problematic. Still, the National Park Service must remain alert for the effects of logging, and coordinate with appropriate federal and state agencies for the implementation of best management practices (BMPs) during and after logging operations.

Four recommended actions address low-priority issues. Two address the impacts of impoundments. These actions also indirectly address the floodplain management issues. These actions are:

Assess Riparian Conditions in New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area
Investigate Effects of River Regulation on Rare Plant Communities.

Two issues address the potential impacts of hazardous material spills. These are:

Determine Travel Time and Dispersion of a Conservative Solute for the Gauley River in Gauley River National Recreation Area
Determine Wave Propagation for the Gauley River in Gauley River National Recreation Area.

The suite of recommended actions represents the concerns to the National Park Service, park users, and park neighbors. The recommended action(s) that address each issue is (are) considered the most reasonable approach at this time. This is based on a host of considerations, including National Park Service policies, public concerns, scientific evidence, technical advice of appropriate experts, and funding options.

The Water Resources Management Plan and NEPA

The National Environmental Policy Act (NEPA) mandates that federal agencies prepare a study of the impacts of major federal actions having a significant effect on the human environment and alternatives to those actions. The adoption of formal plans may be considered a major federal action requiring NEPA analysis if such plans contain decisions affecting resource use, examine options, commit resources or preclude future choices. Lacking these elements, this Water Resources Management Plan (WRMP) has no measurable impacts on the human environment and is categorically excluded from further NEPA analysis.

According to Director's Order (DO) #12 Handbook (section 3.4), water resources management plans normally will be covered by one or more of the following Categorical Exclusions:

- 3.4.B (1) Changes or amendments to an approved plan when such changes have no potential for environmental impact.
- 3.4.B (4) Plans, including priorities, justifications, and strategies, for non-manipulative research, monitoring, inventorying, and information gathering.
- 3.4.B (7) Adoption or approval of academic or research surveys, studies, reports and similar documents that do not contain and will not result in NPS recommendations.
- 3.4.E (2) Restoration of non-controversial native species into suitable habitats within their historic range.
- 3.4.E (4) Removal of non-historic materials and structures in order to restore natural conditions when the removal has no potential for environmental impacts, including impacts to cultural landscapes or archeological resources.
- 3.4.E (6) Non-destructive data collection, inventory, study, research, and monitoring activities.
- 3.4.E (7) Designation of environmental study areas and research natural areas, including those closed temporarily or permanently to the public, unless the potential for environmental (including socioeconomic) impact exists.

These Categorical Exclusions require that formal records be completed (Section 3.2, D0-12 Handbook) and placed in park files. It is the responsibility of the park to complete the documentation for the applicable Categorical Exclusion(s).

INTRODUCTION

PARK LOCATIONS

New River Gorge National River (NERI), Gauley River National Recreation Area (GARI), and Bluestone National Scenic River (BLUE) are located close to each other in southern West Virginia (Figure 1). The National Park Service (NPS) manages these three national park system units (parks) under a unified organization from a central headquarters in Glen Jean. Taken together, these three parks include 94.5 miles of major rivers and a land area of 86,270 acres.

New River Gorge National River is located along a 53-mile stretch of the New River between the towns of Hinton and Fayetteville. The 70,762 acres within the authorized boundary of New River Gorge National River are located in Summers, Raleigh, and Fayette counties (National Park Service 1982, 1996a).

Gauley River National Recreation Area is located along a 25.5-mile stretch of the Gauley River between the towns of Summersville and Gauley Bridge. The park also includes the lower 5.5 miles of the Meadow River. The 11,494 acres within the authorized boundary of Gauley River National Recreation Area are located in Nicholas and Fayette counties (National Park Service 1996a).

Bluestone National Scenic River includes a 12.5-mile stretch of the Bluestone River. The 4,310 acres within the authorized boundary of Bluestone National Scenic River are located in Summers and Mercer counties.

MANAGEMENT AUTHORITY

Specific Laws

New River Gorge National River was authorized by Public Law (PL) 95-625 on November 10, 1978. This park was established for "the purpose of conserving and interpreting outstanding natural, scenic, and historic values and objects in an around the New River Gorge and preserving as a free-flowing stream an important segment of the New River in West Virginia for the benefit and enjoyment of present and future generations…" This law directed the National Park Service to administer, protect, and develop New River Gorge National River in accordance with the National Park Service Organic Act (see below).

Several other federal laws directly address New River Gorge National River. Public Law 99-590 authorized acquiring land for park headquarters at Glen Jean. Public Law 100-71 provided for an 8-year black fly control program in the New River watershed. This law also authorized monitoring to determine the effects of the black fly control program on the environment and recreation. Public Law 100-534 adjusted park boundaries and authorized establishing river access facilities and a visitor center. Other, subsequent

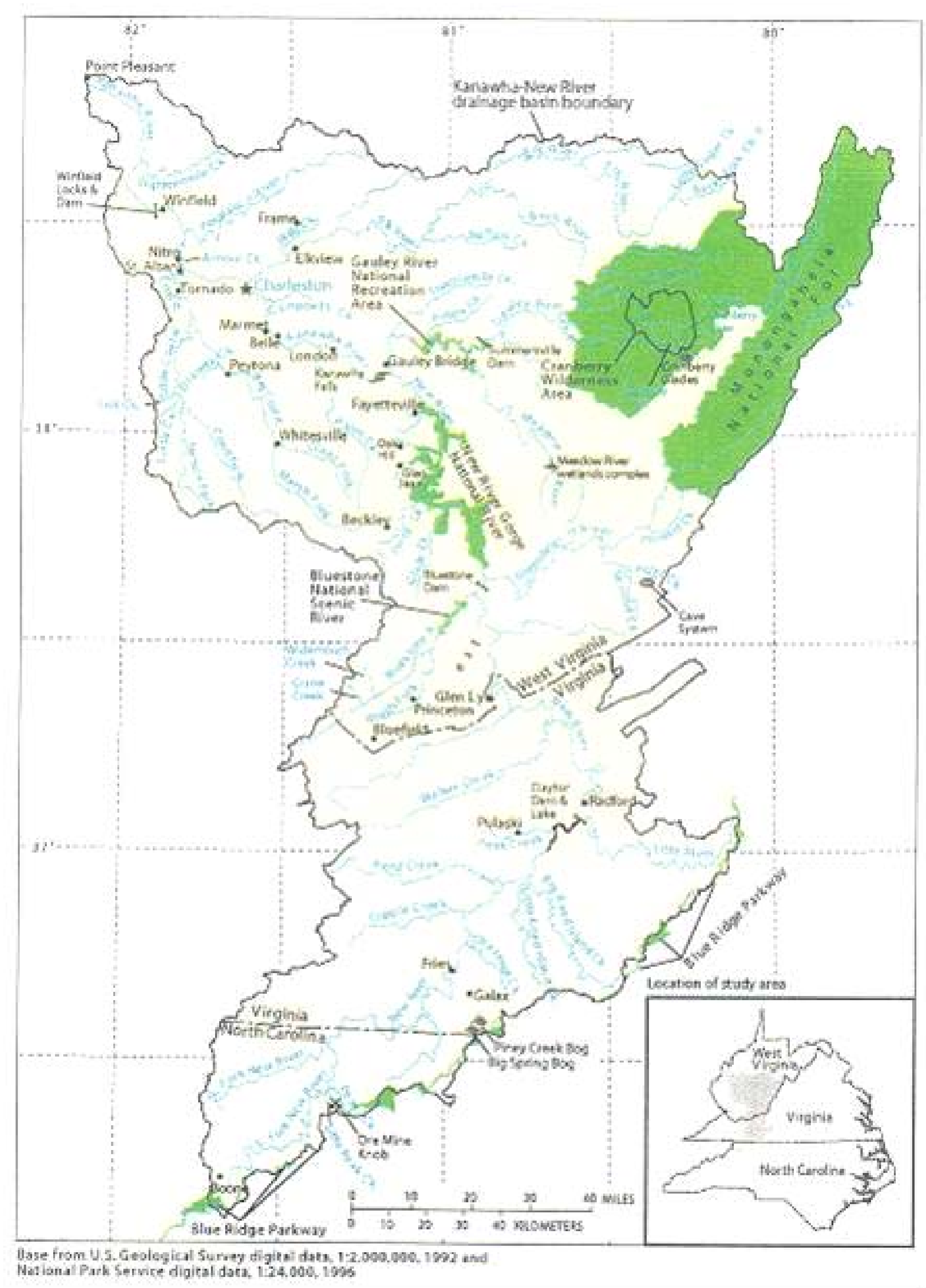


Figure 1. Map showing location of Bluestone National Scenic River, New River Gorge National River, and Gauley River National Recreation Area in southern West Virginia.

laws have also provided for minor boundary adjustments. Public Law 102-154 authorized improvements to Fayette County Road 25. Public Law 102-381 provided funds to replace Fayette Station Bridge across New River at the downstream end of the park. Public Law 102-525 amended the Wild and Scenic Rivers Act (PL 90-542) to determine the suitability of designating an additional 19.5-mile stretch of New River south of the present park as part of the park system.

Gauley River National Recreation Area was established on October 26, 1988 through PL 100-534. This park was established in order to "protect and preserve the scenic, recreational, geological, and fish and wildlife resources of the Gauley River and its tributary, the Meadow River…"

This law also amended the Wild and Scenic Rivers Act (PL 90-542) to designate Bluestone National Scenic River as one of "those rivers…free of impoundments with shorelines or watersheds still largely primitive…undeveloped, but accessible…" The Wild and Scenic Rivers Act declares that included rivers "…be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations." The Wild and Scenic Rivers Act also includes a policy "to protect the water quality of such rivers and to fulfill other vital national conservation purposes."

Several other laws have directly referred to New River Gorge National River. PL 99-590 authorized land acquisition for a park headquarters in Glen Jean, WV. PL 100-71 authorized the State of West Virginia to conduct an 8-year black fly eradication program partly within the park boundary. This law also instructed the park to monitor the impact of the eradication program. PL 102-154 authorized improvements to West Virginia Route 25 within the park, and PL 102-381 provided funds to replace the Fayette Station Bridge near the downstream boundary of the park. Also, PL 102-525 amended the Wild and Scenic Rivers Act to determine the suitability of designating a 19.5-mile reach of the New River south (upstream) of the existing park as part of the national park system.

General Laws

The National Park Service Organic Act (39 Stat. 535) was signed into law on August 25, 1916. This act established the National Park Service, and directed it to "…regulate the use of federal areas known as national parks, monuments, and reservations … so as to conform to the(ir) fundamental purpose". Congress stated the fundamental purpose "…is to conserve the scenery and the natural and historical objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." This last statement is often called the mission of the National Park Service.

The General Authorities Act of 1970 (PL 91-383, 84 Stat. 825) defined the National Park system to "… include any area of land and water now or hereafter administered by the Secretary of the Interior through the National Park Service for park, monument, historic, parkway, recreational or other purposes." This act also stated that areas within the national park system "…though distinct in character, are united through their interrelated purposes and resources…" and that the National Park system be "…preserved and managed for the benefit and inspiration of all the people of the United States…"

This act provided for each park to be administered in accordance with the provisions of any statute made specifically to that area, and that the 1916 Organic Act would also apply to the extent that it did not conflict with such specific statutes. This act cleared up confusion about the mission of many parks, especially newer units with designations such as Historic Parks, Scenic Rivers, National Recreation Areas, and National Seashores. Many of these newer parks had enabling legislation permitting activities that were otherwise incompatible with, or not permitted under, the Organic Act.

The General Authorities Act was amended by the Redwood National Park Expansion Act of 1978 (PL 95-259, 92 Stat.163). A section of this act reaffirmed the mission of the National Park Service. Congress then went further. The Act states "…protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically authorized by Congress."

OTHER LEGAL AUTHORITIES AND CONSTRAINTS

In addition to their specific enabling legislation, other laws specific to individual parks, and general legislation relevant to the National Park Service as a whole, the three parks are subject to various other legal, regulatory, planning, and management authorities (Shelton and Fox 1994). Many other federal and state agencies, individuals, commercial concerns, user groups, and public interest groups have interests in the water and related resources of these three parks. Protecting these resources in the fulfillment of park-specific enabling legislation and overall National Park Service policy requires understanding these various legal, regulatory, and management authorities and constraints.

Federal Authorities

<u>National Environmental Policy Act (42 U.S.C. 4321-4347)</u>

The National Environmental Policy Act (NEPA) created a national environmental policy and provided a formal process for integrating environmental values into federal decision-making. NEPA established the President's Council on Environmental Quality (CEQ), which was charged with developing the legal procedures that all federal agencies must follow in examining the environmental effects of proposed actions.

The procedures developed by CEQ involve three levels of documentation, depending on the potential impact of proposed actions on the human environment. These levels are

Categorical Exclusion (CE), Environmental Assessment (EA), and Environmental Impact Statement (EIS).

For proposed actions not having a significant effect (e.g. addition of new overhead utility facilities to existing poles), a CE is prepared that documents the facts relevant to such a decision. If a proposed action is not categorically excluded, an EA is prepared. If the EA determines that all potentially significant environmental effects can be mitigated, and the proposed action is not likely to generate significant controversy, a Finding of No Significant Impact (FONSI) can be issued. After the FONSI is issued, the proposed action may commence. If the effects of the proposed action cannot be mitigated, is likely to generate significant controversy, or constitutes a major federal action, an EIS must be prepared. If it is readily apparent to the responsible agency that an EIS is required, the preliminary EA is usually omitted.

Analysis in an EIS is usually much more detailed than in an EA. The agency first holds one or more public scoping sessions where potentially significant issues and alternative actions are described. The agency then prepares a draft EIS, which evaluates the potential actions and the significant issues related to those actions. The draft EIS is then made available for public review. Comments on the draft EIS from federal, state, local agencies, and the public must be addressed in the final EIS. The conclusion of this process is the issuance of a record of decision (ROD). The ROD states the decision made by the agency, alternatives considered, factors involved in the decision, and any mitigating measures required. After issuance of the ROD, the proposed action may be undertaken, unless challenged in court.

Clean Water Act (33 U.S.C. s/s 1251 *et seq.*)

The purpose of this act "…is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". One national goal of this act was the elimination of pollutant discharge into navigable waters by 1985. An interim goal was to attain water quality that provided for the protection and propagation of fish, shellfish, and wildlife and provided for recreation in and on the water be achieved by July 1, 1983. Several parts of the Clean Water Act are pertinent to National Park Service management of the three parks.

States are required to promulgate water quality standards. Each state must review its standards at least once every three years. States must list waters where effluent limitations are not stringent enough to implement any water quality standard. For each body of water listed, the state must establish total maximum daily loads (TMDLs) for applicable pollutants.

This act established the National Pollutant Discharge Elimination System (NPDES). This system requires every point source discharge of pollutants to streams and rivers to acquire a permit. Amendments in 1987 required states to implement programs to regulate non-point source pollution, and added stormwater runoff from industrial, municipal, and construction sites to the NPDES program.

The Clean Water Act also includes a provision from the Water Quality Improvement Act of 1970. This provision dictates that applicants for a federal license or permit for actions that will result in a discharge into waters of the United States obtain certification that such discharge will comply with applicable water quality standards from the state agency responsible for water pollution control.

Section 404 of the Clean Water Act regulates the discharge of dredged or fill materials into waters of the United States, including wetlands. The U. S. Army Corps of Engineers administers activities covered under this part of the Act, with oversight and veto powers held by the U. S. Environmental Protection Agency.

Safe Drinking Water Act (42 U.S.C. s/s 300f *et seq*.)

This Act was established to protect the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources.

The Act authorized EPA to establish safe standards of purity and required all owners or operators of public water systems, including the National Park Service, to comply with primary (health-related) standards. State governments, which assume this power from EPA, also encourage attainment of secondary standards (nuisance-related).

Endangered Species Act (7 U.S.C. 136; 16 U.S.C. 460 *et seq*.)

This 1973 law and its 1978, 1982, and 1988 amendments are a powerful tool for the preservation and recovery of rare or declining species. Section 3 defines "endangered species" as any species in danger of extinction, and "threatened species" as any species likely to become endangered. Section 7 requires federal agencies to consult with the U.S. Fish and Wildlife Service if their activities may affect a species listed as threatened or endangered.

Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq*.)

The purpose of this act is to ensure that "… wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs." This act requires federal agencies to consult with the U.S. Fish and Wildlife Service (or in some cases the National Marine Fisheries Service), and the parallel state agencies, if proposed water resource development actions would result in alteration of a body of water.

Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. s/s 135 *et seq*.)

This law regulates the use of pesticides. It requires certification for applicators of certain dangerous pesticides. The law gives EPA the authority to delegate to individual states the authority to write and enforce more stringent pesticide laws.

Exotic Organisms, Invasive Species (Executive Orders 11987, 13112)

Executive Order (EO) 11987 requires Federal agencies, to the extent permitted by law, to restrict the introduction of exotic species into the natural ecosystems on lands and waters owned or leased by the United States. Federal agencies are also required to encourage States, local governments, and private citizens to prevent the introduction of exotic species into natural ecosystems of the United States. It also restricts the importation and introduction of exotic species into any natural U.S. ecosystems as a result of activities that Federal agencies undertake, fund, or authorize.

Executive Order 13112 is designed to prevent the introduction of invasive species and provide for their control, as well as to minimize the economic, ecological, and human health impacts that invasive species cause.

Floodplain Management (EO 11988)

This order requires federal agencies to "reduce the risk of flood loss, …minimize the impacts of floods on human safety, health, and welfare, and…restore and preserve the natural and beneficial values of floodplains." It requires federal agencies to implement floodplain planning and to consider all feasible alternatives which minimize the impacts of flooding prior to the construction of facilities and structures, which are to be located outside of the floodplain if at all possible. Construction of park facilities must be consistent with federal flood insurance and floodplain management programs. Guidance applicable to the National Park Service for implementing EO 11988 is contained in National Park Service (1993a).

Protection of Wetlands (EO 11990, Director's Order No. 77)

This order requires federal agencies to "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands." Unless no practical alternatives exist, Federal agencies must avoid activities in wetlands that might adversely affect the ecosystem. Guidance for Director's Order No. 77, which superceded Executive Order 11990, is contained in National Park Service Procedural Manual 77.1: Wetlands Protection (National Park Service 1998b).

American Heritage Rivers Initiative (EOs 13061, 13080, 13093)

Executive Order 13061 (September 11, 1997) established the American Heritage Rivers Initiative to provide Federal support of community efforts along designated rivers. Executive Order 13080 (April 7, 1998) established the American Heritage Rivers Initiative Advisory Committee to review nominations from communities and recommend to the President rivers for consideration for designation as American Heritage Rivers. Executive Order 13093 (July 27, 1998) increased the number of rivers that the President could designate to twenty.

National Park Service Regulations

Each federal agency, under authority established by Congress, establishes regulations for fulfilling its mission. For the National Park Service, Management Policies (National Park Service 2001) provide the basic guidance for managing the National Park System. This document includes such topics as park planning, land protection, and resource management. More specific procedures for implementing policy are described in a series of Director's Orders (DOs). Director's Orders most directly pertaining to water resources include:

DO – 2	the planning process
DO – 12	compliance with NEPA
DO – 75	natural resources inventory and monitoring
DO – 77	management of natural resources
DO – 83	public health management

State of West Virginia Statutes and Designations

Many of the West Virginia regulations pertaining to water resources are listed in Titles 46 and 47. Listed below are Series and Sections of the State regulations, which may be of interest to the parks. The State codes are not listed because they change annually and are subject to revision at any time. State water-quality standards, which are divided into several categories, are similar but not identical to EPA standards.

<u>Title 46 – Environmental Protection – Environmental Quality Board</u>

Series 1 – Requirements Governing Water Quality Standards
Series 6 – Procedural Regulations for the Revision of Water Quality Standards
Series 12 – Requirements Governing Groundwater Standards

<u>Title 47 – Division of Environmental Protection – Office of Water Resources</u>

Series 10 – State/National Pollutant Discharge Elimination System Regulations
Series 11 – Special Regulations (spills, accidental discharges, some water treatment and waste allocation regulations)
Series 11A – Waste Loads
Series 30 – WV/NPDES Regulations
Series 34 – Dam Safety Regulations
Series 57 – Groundwater Quality Standard Variances
Series 58 – Groundwater Protection Regulations

LANDOWNERSHIP

The National Park Service does not own all of the land within the authorized boundaries of the three parks. Within New River Gorge National River, the NPS owns 42,967 acres

(61%). The State of West Virginia owns 3,637 acres (5%) in the form of Babcock State Park. The remaining 23,862 acres (34%) are privately owned. Within Gauley River National Recreation Area the NPS owns 4,020 acres (35%). The U. S. Army Corps of Engineers owns about 43 acres (less than 1%), with the remaining 7,431 acres (65%) being privately owned. Within Bluestone National Scenic River the NPS owns 3032 acres (70%), the State of West Virginia owns 1,236 acres (29%) in the form of Pipestem State Park, and 41 acres (<1%) are in private ownership.

The above figures were accurate as of December 3, 2002. The NPS is authorized to acquire lands within the authorized boundaries of the three parks. Lands are acquired only if they meet park purposes and management objectives, and sufficient funding is provided by Congress. Acquisition occurs by donation (rarely) or purchase on a willing buyer - willing seller basis (most often). As a result of land acquisitions, NPS-owned acreage within New River Gorge National River and Gauley River National Recreation Area is steadily increasing. As of December 6, 2002 the NPS is closing purchases on two parcels in New River Gorge National River that total 15.6 acres.

Information on ownership and acreage of in-holdings located within park boundaries is maintained at the NPS land office in Oak Hill, West Virginia. Most mineral rights are maintained by prior landowners and are not kept on file in the land office.

LAND COVER AND LAND USE

Information in this section was obtained from West Virginia Division of Environmental Protection (WVDEP) online databases (West Virginia Division of Environmental Protection 1999a). These databases are catalogued by hierarchical Hydrologic Unit codes developed by the U. S. Geological Survey (USGS) (Seaber *et al.* 1987). These codes are noted in parentheses following the name of the watershed in the following discussion. Land use of private property within the boundaries of the three parks has not been categorized.

New River Gorge National River lies in the Lower New River Watershed (05050004). This watershed is divided into 10 sub-watersheds (Figure 2, Table 1). Predominant land cover is forest. Deciduous forest comprises from 55.77 to 84.96% of the ten sub-watersheds. Mixed (3.50 to 15.33%) and conifer (0.20 to 6.75%) forests are also common. The most developed sub-watersheds are Piney Creek (city of Beckley; 7.94%) and Dunloup Creek (city of Mount Hope; 2.51%). Developed lands are less than 2% of the other sub-watersheds. Farmland (including hay, pasture, grasslands, and croplands) comprises less than 10 percent of all sub-watersheds except Upper Meadow Creek (21.23%), Piney Creek (15.33%), and Glade Creek (12.49%). Wetlands, mainly riverine, range from 0.28 to 2.44% of each sub-watershed.

There are 94 surface and 59 underground mining permits in the Lower New River Watershed. The Piney Creek sub-watershed has the greatest numbers of both surface (27), and underground (30), permits.

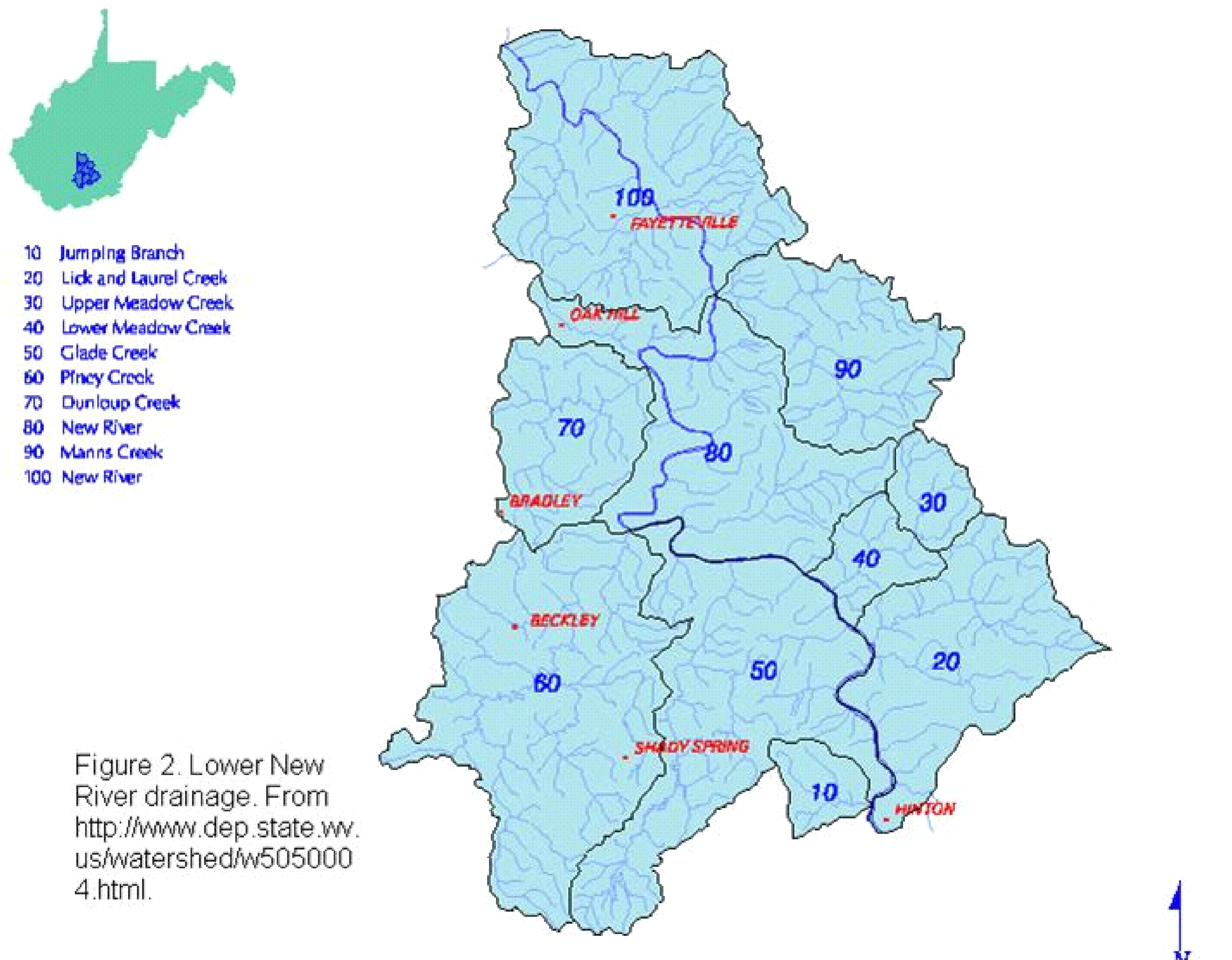


Figure 2. Lower New River drainage. From http://www.dep.state.wv.us/watershed/w5050004.html.

Table 1. Land Use for Lower new River Drainages. # refers to code on Figure 2.

#	Name	Sq. Mi.	% Developed	% Agriculture	% Forested	% Wetlands	Toxic Releases, lbs. 1987-96	Surface Mining Permits	Underground Mining Permits
10	Jumping Branch	13	0.05	8.36	90.97	0.15	0	1	0
20	Lick and Laurel Creek	78	0.61	6.27	89.70	1.16	0	2	0
30	Upper Meadow Creek	15	0.51	21.23	76.61	0.69	0	7	0
40	Lower Meadow Creek	17	0.24	7.75	89.33	1.26	0	2	1
50	Glade Creek	106	0.24	12.49	84.16	2.39	0	1	12
60	Piney Creek	135	6.94	15.33	76.61	0.41	0	27	30
70	Dunloup Creek	48	2.51	7.05	88.09	0.28	0	22	1
80	New River	95	1.36	5.27	90.00	2.44	0	14	7
90	Manns Creek	58	0.12	7.95	87.60	0.77	0	12	7
100	New River	121	1.65	8.44	88.22	1.31	0	6	1

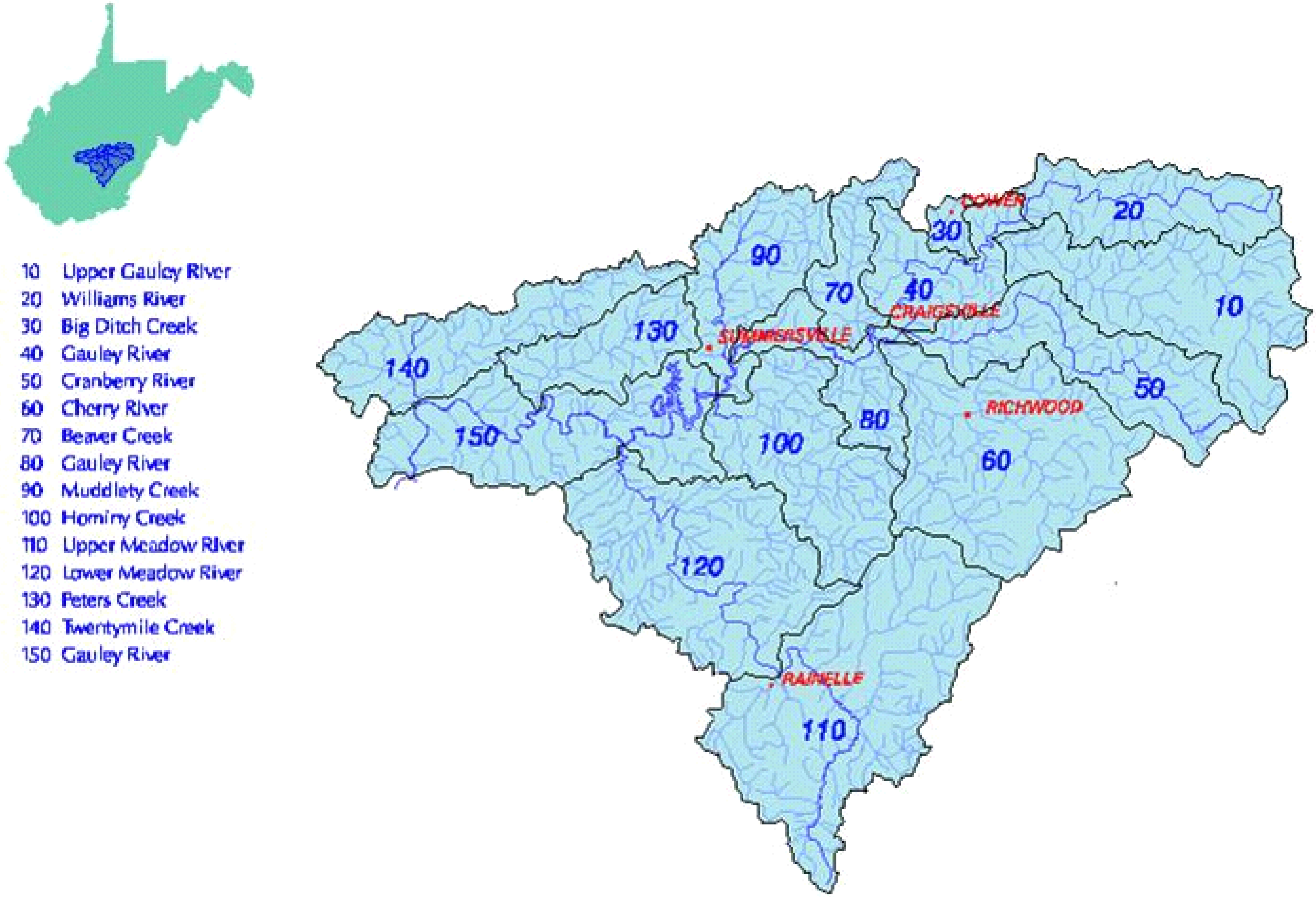


Figure 3. Gauley River drainage. From http://www.dep.state.wv.us/watershed/w5050005.html.

Table 2. Land Use for Gauley River Drainages. # refers to code on Figure 3.

#	Name	Sq. Mi.	% Developed	% Agriculture	% Forested	% Wetlands	Toxic Releases, lbs. 1987-96	Surface Mining Permits	Underground Mining Permits
10	Upper Gauley River	129	0.01	2.52	96.72	0.45	0	1	0
20	Williams River	70	0.18	1.37	97.86	0.21	0	5	10
30	Big Ditch Creek	9	1.96	1.03	77.97	1.92	0	1	0
40	Gauley River	57	0.87	10.27	86.89	1.24	0	11	2
50	Cranberry River	96	0.01	0.65	98.07	1.11	0	0	1
60	Cherry River	166	0.33	1.59	96.54	0.37	0	18	22
70	Beaver River	38	0.59	17.61	72.73	3.01	0	41	12
80	Gauley River	48	0.25	8.03	88.74	2.01	0	18	8
90	Muddlety Creek	73	1.29	13.1	79.34	2.00	0	56	28
100	Hominy Creek	103	0.18	10.05	88.07	0.49	0	12	9
110	Upper Meadow River	205	0.48	12.8	79.82	4.55	0	47	35
120	Lower Meadow River	160	0.24	7.2	90.07	0.97	0	14	14
130	Peters Creek	53	0.23	7.98	88.19	0.24	0	35	28
140	Twentymile Creek	87	0.15	1.53	93.81	0.10	0	17	35
150	Gauley River	127	0.29	6.82	87.57	4.16	0	23	18

Gauley River National Recreation Area lies in the Gauley River Watershed (05050005). This watershed is subdivided into 15 sub-watersheds (Figure 3, Table 2). Predominant land cover in the watershed is deciduous forest, ranging from 45.40 to 78.65% of each sub-watershed. Mixed and conifer forests range from 3.40 to 28.08% and 0.36 to 25.67%, respectively, of each sub-watershed. Developed lands are less than 2% of each sub-watershed. Farmlands comprise 0.65 to 18.03%, and wetlands comprise 0.10 to 4.55% of each sub-watershed.

There are 299 surface and 222 underground mining permits in Gauley River Watershed. The largest numbers (56 surface, 28 underground) are upstream of Summersville Dam in the Muddlety Creek sub-watershed. For sub-watersheds that flow directly into the park, Upper Meadow River has 47 surface and 35 underground permits, and Peters Creek has 35 surface and 28 underground permits.

Bluestone National Scenic River is in the Upper New River Watershed (05050002). This watershed is divided into 13 sub-watersheds (Figure 4, Table 3). Deciduous forests range from 26.75 to 80.01% of each sub-watershed. Mixed and conifer forests range from 4.855 to 17.84% and 0.37 to 11.00%, respectively, of each sub-watershed. Developed lands are less than 4% of each sub-watershed, except Dave's Fork and Christian Fork (16.48%) and Brush Creek (8.60%). Farmlands comprise 9.06 to 42.83%, and wetlands comprise 0.05 to 3.64%, of each sub-watershed.

There are seven surface and eight underground mining permits in the Bluestone River watershed. Six of these are located in the Middle Bluestone and Lower Bluestone River sub-watersheds. Appreciable coal mining occurs in the upper Bluestone watershed in Virginia.

As noted above, most land in and adjacent to the parks is forested. Most timber in these forests is considered harvestable. Active logging occurs near, and adjacent to, the parks.

Coal mining has been a major land use in West Virginia for many years (West Virginia Geological and Economic Survey 1999a). By 1840 statewide coal production had reached 300,000 tons. Peak years were 1927 (over 146 million tons) and 1947 (over 173 million tons). By 1880 extensive mining occurred in Fayette County. In 1914 large-scale surface mining commenced. By 1936 mechanization (shuttle cars, conveyor belts, and long trains) spread rapidly through the coalfields. Development of huge shovels and draglines has facilitated surface mining in recent years.

Coal is mined in watersheds draining to all three parks. Surface and underground mining of coal has impacted, and could further impact, each park. Surface mining of coal by the mountaintop removal/valley fill method in Nicholas County could impact water quality and degrade scenic beauty in and near Gauley River National Recreation Area. Mining in areas projected for mountaintop removal (Figure 5) would probably have little or no impact on New River Gorge National River, and no impact on Bluestone National Scenic River, due to the distance of these parks from projected mining areas. Some mountaintop

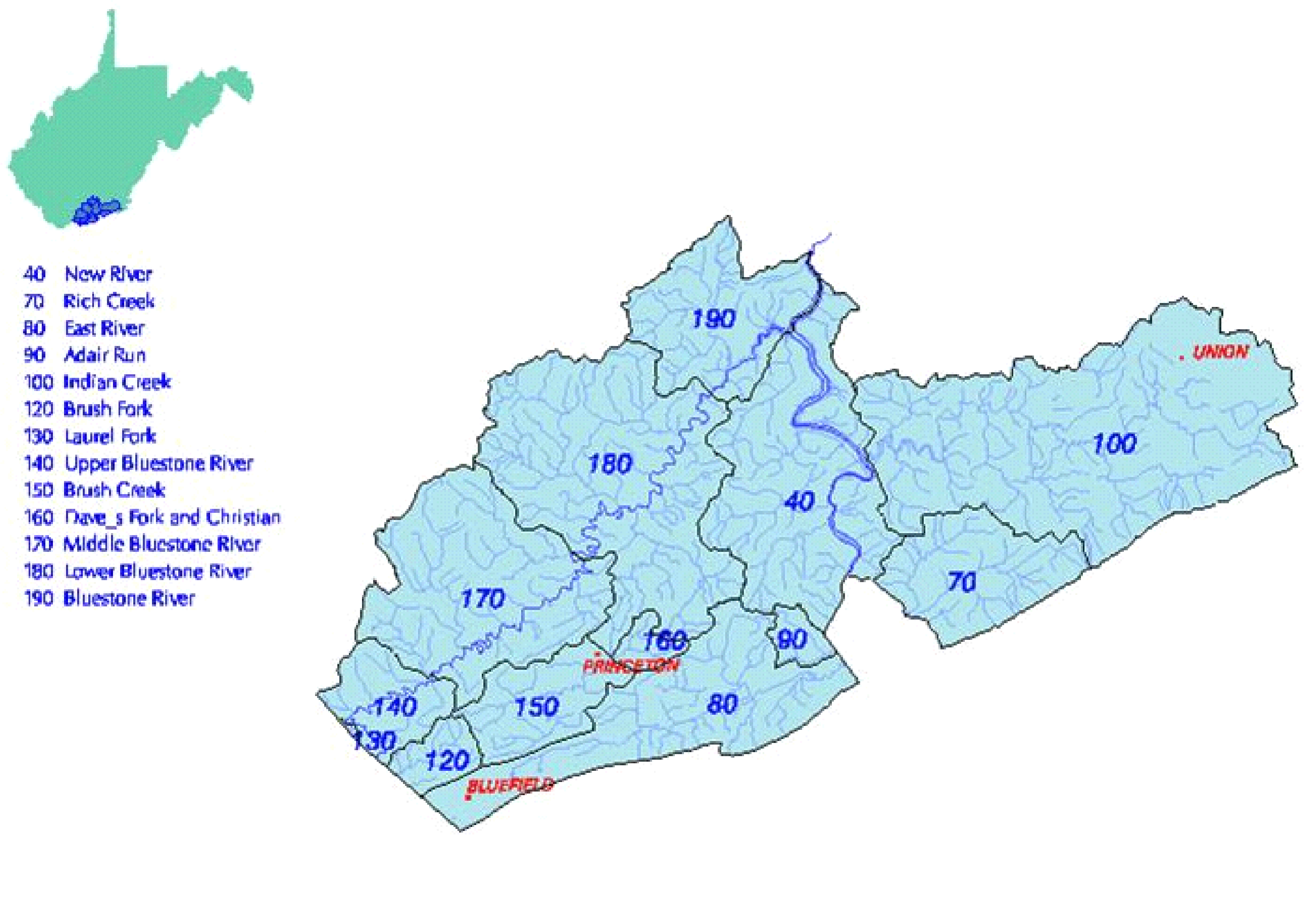


Figure 4. Upper New River drainage including Bluestone River. From http://www.dep.state.wv.us/watershed/w5050002.html.

Table 3. Land Use for Upper New River Drainages. # refers to code on Figure 4.

#	Name	Sq. Mi.	% Developed	% Agriculture	% Forested	% Wetlands	Toxic Releases, lbs. 1987-96	Surface Mining Permits	Underground Mining Permits
40	New River	105	0.12	13.94	81.55	3.64	0	0	1
70	Rich Creek	48	0.94	42.40	56.46	0.15	0	0	0
80	East River	83	3.08	10.14	86.17	0.07	0	0	0
90	Adair Run	7	0.03	14.66	85.23	0.05	0	0	0
100	Indian Creek	191	0.2	35.55	63.88	0.27	0	0	0
120	Brush Fork	12	4.12	26.70	68.48	0.68	0	0	0
130	Laurel Fork	0	3.15	9.06	87.79	0.14	0	0	0
140	Upper Bluestone River	26	1.52	10.03	88.11	0.28	0	0	0
150	Brush Creek	33	8.60	23.46	65.89	1.54	0	0	0
160	Dave's Fork and Christian	7	16.48	42.83	39.92	0.63	0	0	0
170	Middle Bluestone River	97	0.6	13.32	84.55	0.29	0	5	6
180	Lower Bluestone River	135	0.96	16.58	81.71	0.60	0	2	1
190	Bluestone River	55	0.09	12.91	84.78	2.18	0	0	0

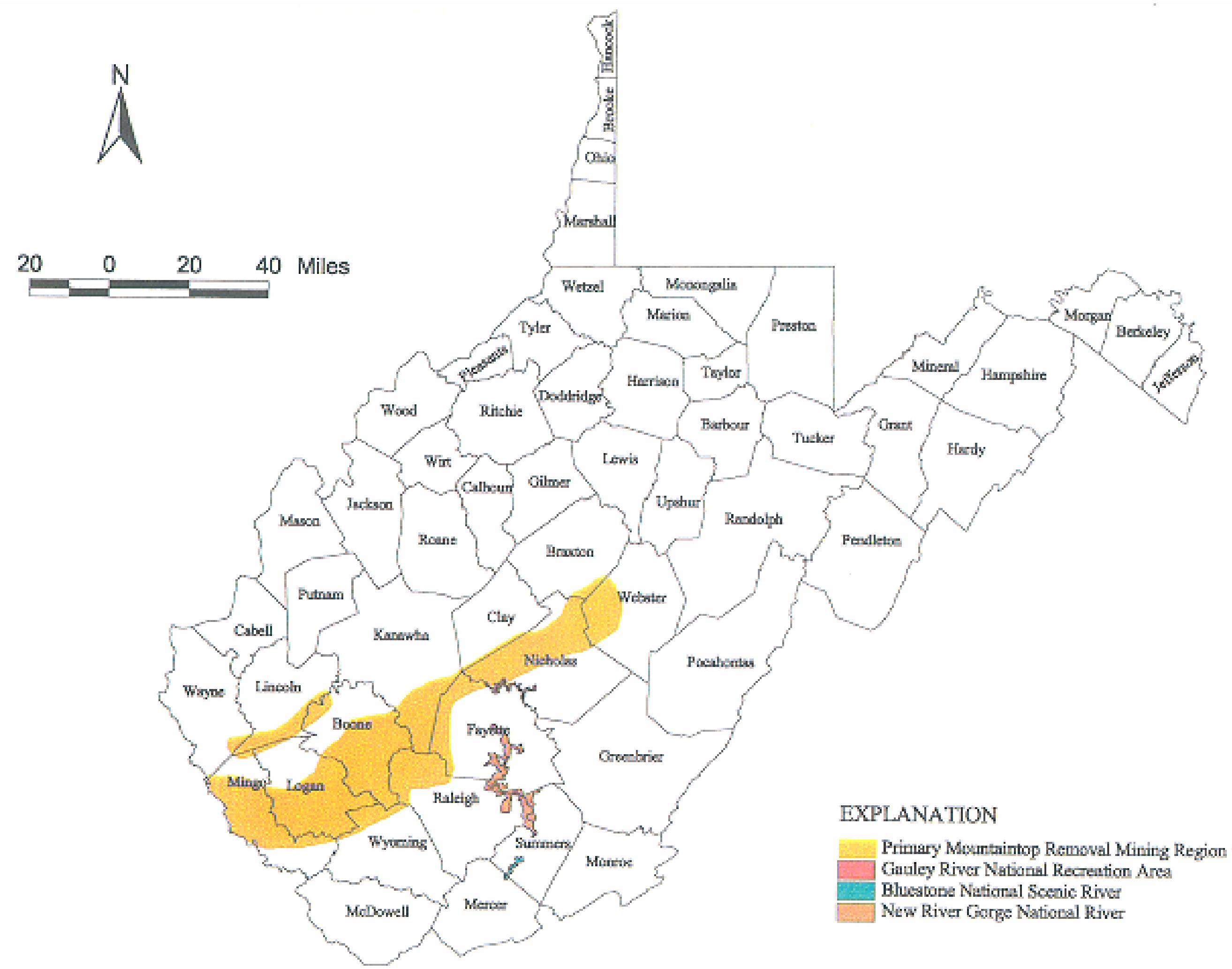


Figure 5. Approximate region of present and projected major mountaintop removal mining activity in West Virginia. After West Virginia Geological and Economic Survey (1998).

removal mining has occurred outside the projected area. Expansion of this trend might impact New River Gorge National River and Bluestone National Scenic River.

Coal production in Fayette County (NERI, GARI) increased from 1.2 million tons in 1987 to 4.1 million tons in 1996, with a peak of 5.4 million tons in 1994. Most of this production was from surface mines. Production in Mercer County (BLUE) between 1991 and 1994 was about 300,000 tons, all of which came from surface mines. Production in Nicholas County (GARI) between 1986 and 1996 peaked at 9.3 million tons in 1988, dropping to 2.7 million tons in 1996. Surface mining accounted for most of this production except in 1986 and 1996. Production in Raleigh County (NERI) increased from 7.2 million tons in 1986 to 13.6 million tons in 1996. About 90 percent of this production came from underground mines. Production in Summers County (NERI, BLUE) was less than 3,900 tons in 1986 and about 145,000 tons in 1994. All of this came from surface mines.

Oil and gas extraction is another important land use in West Virginia (West Virginia Geological and Economic Survey 1999c). In the early 1800's salt manufacturers encountered oil and gas while drilling for salt. At the time they were considered nuisances because they had no value. Salt manufacturers diverted so much oil to the Kanawha River that it was known as "Old Greasy" to boatmen. In 1859 a salt well near Burning Springs struck oil and produced 200 barrels per day when deepened. A second, nearby well yielded 1,200 barrels per day. Thus began the oil and gas industry in West Virginia.

Burning Springs was one of only two oil fields present in America before the Civil War. Development of deeper drilling techniques, well pump mechanization, and the theory of anticlinal accumulation of oil and gas led to expansion of oil production in West Virginia. Oil production peaked in 1900 at 16 million barrels. While oil production declined after 1900, gas production increased. West Virginia led the nation in gas production from 1906 to 1917. Gas production declined from 1917 to 1934, then increased again until 1970.

Production of oil and natural gas between 1979 and 1999 for the five counties in which the parks are located is negligible (West Virginia Geological and Economic Survey 1999d). In Fayette County (NERI, GARI) annual natural gas production in thousands of cubic feet (Mcf) ranged from a minimum of 2.5 million in 1989 to a maximum of 5.9 million in 1981, with roughly 4.0 million produced each year between 1990 and 1999. The number of producing wells increased from 119 in 1979 to 611 in 1999. Natural gas production in Nicholas County (GARI) varied from 1.8 million in 1985 to 5.3 million in 1981, with 2.1 million produced in 1999. The number of producing wells increased from 102 in 1979 to 383 in 1999. Natural gas production in Raleigh County (NERI) varied from 2.1 million in 1979 to 5.2 million in 1988, with 4.3 million produced in 1999. Natural gas production in Mercer County (BLUE) varied from about 191,000 in 1979 to 1.3 million in 1993, with about 1.2 million produced in 1999. The number of producing wells increased from 15 in 1979 to 135 in 1999. Only two wells in Summers County (NERI, BLUE) produced gas and only in 1999. Total volume produced was 16,326 Mcf.

VISITATION

Annual visitation to New River Gorge National River grew from a little over 230,000 in 1985 to over 1,230,000 in 2000. Peak visitation occurs in July. Most visitors stop at the Canyon Rim Visitor Center. Each year between 1994 and 2001 approximately 150,000 visitors took commercially operated white water trips through New River Gorge. Based on data from Gauley River National Recreation Area (see below), an additional 10%, or 15,000 private boaters descended New River Gorge. Statistics are not available on angling use within New River Gorge National River.

Annual visitation to Gauley River National Recreation Area between 1993 and 2000 averaged almost 230,000. Peak visitation occurs in September and October during Gauley Season. Each year between 1994 and 2001 approximately 61,500 people took commercial white water trips down the Gauley River within Gauley River National Recreation Area. Approximately 64% (39,000+) of these trips originate at the Summersville Dam tailwaters (upper Gauley), with the remainder putting on at Mason Branch (lower Gauley). Based on data from 1984 through 1992, private boaters putting on the Gauley River at the tailwaters each year averaged about 10% of commercial boaters. At recent visitation rates, this amounts to about 4,000 private boaters. No statistics are available on angling use within Gauley River National Recreation Area.

Annual visitation to Bluestone National Scenic River between 1993 and 2000 averaged a little over 60,000. Peak use occurs in July. Commercial river outfitters generally do not operate in Bluestone National Scenic River due to the shallow nature of Bluestone River. Statistics are not available on angling use within Bluestone National Scenic River.

PURPOSE OF THE WATER RESOURCES MANAGEMENT PLAN

Enabling legislation of the three parks requires the National Park Service to conserve and interpret natural, scenic, and historic values in and around the river corridors and to maintain the rivers as free-flowing streams. At the same time, the National Park Service must facilitate public use, both now and in the future. To achieve these goals, National Park Service policy requires each park to develop and implement a general management plan (GMP). A GMP for New River Gorge National River was completed in 1982 (National Park Service 1982). This GMP is scheduled for an update in 2004. A resource management plan (RMP) that addressed issues for all three parks was prepared in 1994 (National Park Service 1994a). The RMP is updated annually.

Any park with significant water resources, or where water resource issues are complex, numerous, or controversial, should consider the development of a water resource management plan (WRMP). A WRMP identifies and analyzes water-related issues and describes actions to address these issues. A Water Resources Scoping Report (National Park Service 1996a) evaluated the water resources issues facing the three parks, and recommended development of a comprehensive WRMP to address these issues. This WRMP satisfies the 1996 recommendation by describing water-resource issues which may threaten natural, scenic, and historic values in and around the New, Gauley, and

Bluestone rivers, and by providing management actions to address these issues. This plan is designed to guide water-related activities in the three parks for the next 5-10 years.

WATER RESOURCE MANAGEMENT OBJECTIVES

Original objectives for this WRMP were first identified in the Water Resources Scoping Report (National Park Service 1996a). After meeting with interested federal, state, and local agencies, groups, and organizations in November of 1998, the initial objectives were somewhat modified. This modified list of 15 objectives for the WRMP is presented below. The goal of these objectives is to provide effective management of the extensive water-related resources of the three parks, and to preserve significant ecosystem functions and values.

1. Manage park water resources and activities which may influence or be dependent upon water resources, in accordance with the National Park Service Organic Act, the Redwood Park Expansion Act, enabling legislation for each park, other pertinent legislation, applicable executive orders, National Park Service management policies, and other appropriate regulations.

2. Manage park waters and water dependent environments to maintain the highest degree of biological diversity and ecosystem integrity consistent with the natural potential water quality and biotic potential for these waters.

3. To the extent possible given existing dams and diversions, maintain natural stream flow regimes and stream geomorphic characteristics in park waters.

4. Assure that park development and operations do not adversely affect the park's water resources and water dependent environments.

5. Promote public awareness and understanding of current and potential human impacts upon water resources, the natural hydrologic cycle, the importance and significance of natural aquatic ecosystems, and the National Park Service role in protecting water resources in the three parks.

6. Contribute to the scientific base for water and aquatic resources through appropriate research, inventory, and monitoring. Use sound science in the management of these resources.

7. Strive to seek and maintain the highest possible level of protection under state and federal water quality standards for park waters.

8. Protect National Park Service water and water related resources from the adverse impacts of channel disturbance activities. Specifically, protest all applications for Clean Water Act section 404 permits within park boundaries, as well as those outside park boundaries which have the potential to adversely affect park resources.

9. Acquire sufficient knowledge about water quality, both in general terms and as it specifically relates to water resources relevant to the three parks, to effectively participate in state and local water resource management planning.

10. Evaluate the status of current knowledge regarding water resources relevant to the three parks. Where gaps are identified, acquire appropriate baseline information to adequately understand and manage water resources and meet National Park Service inventory and monitoring requirements.

11. Minimize the risks of injury and property damage resulting from floods, putting particular reliance on National Park Service Floodplain Management Guidelines. Specifically, ensure that National Park Service facilities are not located in flood hazard areas.

12. Develop and implement cooperative management efforts to protect rare species, particularly those listed as threatened or endangered under the Endangered Species Act, which depend upon park resources.

13. Detect and evaluate external influences that may impact National Park Service water resources and water related attributes.

14. Delineate riparian wetlands, and monitor and manage these resources in a manner that will maximize their biological integrity and enhance critical habitat for fish and wildlife.

15. Ensure that permitted oil and gas operations are accomplished with minimal impact to both surface and underground water resources.

OTHER PLANNING EFFORTS

A number of federal, state, regional, local, and private agencies and groups are involved in planning activities that are relevant to management of water and related resources in the three parks. This section describes those planning activities, and relates them to water resource issues of the three parks.

On July 27, 1998, the New River was designated as one of the first 14 American Heritage Rivers (AHR). This designation includes all of the New River, including tributaries, and its watershed, from the headwaters to the mouth. This area includes all of the 21 counties through which the New River passes. The AHR program streamlines access to federal resources for community-based programs and projects in watersheds of designated rivers. These programs and projects may fall under any of four areas: economic revitalization, natural resource protection, historic and cultural preservation, and education and training. New River Community Partners (NRCP) was created as a non-profit organization to coordinate AHR efforts in the New River. A federal employee serves as River Navigator. This person serves as a liaison to federal agencies, helping the partners identify funding opportunities, connect with federal programs, and obtain information and resources. At present the Navigator is Ben Borda of the U.S. Army Corps of Engineers (COE), Huntington, WV, District. Interested parties gathered in 1998 and 1999 to put together a work plan (New River Community Partners 1999) of potential projects within the New River watershed. Several NERI employees participated in this process, and continue to participate in AHR activities.

In 1999, several federal agencies signed a Memorandum of Understanding (MOU) to collaborate on resolving complex environmental issues in the Mid-Atlantic region. Collectively, these agencies are known as the Mid-Atlantic Federal Partners for the Environment ("Federal Agencies Committed to Conserving, Managing and Protecting the Region's Natural Resources"). This MOU replaced an earlier MOU ("The Highlands Accord") that expired on September 30, 1999. Department of the Interior agencies signing the MOU were National Park Service, USGS, Fish and Wildlife Service (FWS), Bureau of Land Management (BLM), and Office of Surface Mining (OSM). Other signatories included Environmental Protection Agency (EPA), Forest Service (FS) and Natural Resources Conservation Service (NRCS) in the Department of Agriculture, COE (Department of Army), and National Marine Fisheries Service (NMFS) (Department of Commerce). Agencies signing the MOU will work together and with the states, tribes, local governments, and other parties toward a more integrated and comprehensive approach to the management, conservation, restoration and protection of natural resources in the Mid-Atlantic States. Signing agencies agreed to cooperate in environmental endeavors on a volunteer basis, and to meet twice a year to review and discuss cooperative programs. Currently, meetings are held four times a year. The Regional Director of the Northeast Region represents the NPS at these meetings.

The National Water Quality Assessment (NAWQA) Program of the USGS began in 1991 (Cohen *et al.* 1988, Hirsch *et al.* 1988, Leahy *et al.* 1990, National Research Council 1990, Alley and Cohen 1991, Gilliom *et al.* 1995). The three major goals of this program are to (1) document the quality of a large, representative part of the Nation's water resources, (2) define water quality trends, and (3) identify major factors that affect water quality. This program emphasizes data collection across media to assemble multiple lines of evidence to support the three major goals. In addressing these goals, the program produces water quality information useful to National, State, and local policymakers and water managers.

The Kanawha-New River Basin study unit was one of the hydrologic systems that formed the building blocks of NAWQA. Assessment activities in this study unit began in 1994, with high-intensity data collection occurring during 1996-98. Data were published annually (Ward *et al.* 1997, 1998, 1999). Several interpretive reports have resulted from this work (Messinger 1997, Messinger and Hughes 2000, Kozar *et al.* 2000, Paybins *et al*. 2000, Chambers and Messinger 2001, and Messinger and Chambers 2001). Due to changes in program priorities, USGS decided not to fund the Kanawha-New River Basin study unit after FY 2001. One additional report, comparing certain findings from this study unit with those of the Allegheny-Monongahela River Basin study unit, may be published later, while a report analyzing overall stream water chemistry in the Kanawha-New River Basin unit has been dropped (Doug Chambers, U.S. Geological Survey, personal communication 2002).

The Appalachian Clean Streams Initiative is administered by the Office of Surface Mining, Reclamation and Enforcement (OSM) of the U. S. Department of the Interior. The Initiative began in 1994 as a broad-based program to eliminate acid drainage from abandoned coalmines. Using a combination of private and governmental resources, this program facilitates and coordinates citizen groups, university researchers, the coal industry, corporations, the environmental community, and local, state, and federal government agencies that are involved in cleaning up streams polluted by acid mine drainage (< http://www.osmre.gov/acsihome.htm >). The coalfields in and adjacent to the three parks typically contain low sulfur coal that does not produce acid drainage. Acid drainage has been noted in the Wolf Creek watershed that is tributary to New River. This acid drainage originates from a pile of coal waste (gob) that was imported from one or more other watersheds.

Water resources management within the state of West Virginia generally falls under the domain of the WV DEP. Among the programs administered by agency, many are relevant to the three parks. These programs revolve around the issues of watershed management and water quality. Much of the information that follows was obtained from the agency's web site (< http://www.dep.state.us/wr >), with additional clarification from WV DEP staff members Jessica Welsh and Janice Smithson.

The Watershed Management Framework program is West Virginia's comprehensive approach to managing the state's waters and their surrounding ecosystem (West Virginia Watershed Management Workgroup 1998). This program provides a coordinated manner for government agencies, interested parties, and citizens to help identify streams that need restoration, protection, or enhancement.

Watersheds were divided into five groups, with each group undergoing a 5-year management cycle. This cycle is scoping and screening activities the first year, strategic monitoring and assessment the second year, management strategy development the third year, development of priority watershed management plans the fourth year, and implementation of point and non-point source activities the fifth year. The first cycle of this process was completed in 2000, and the second cycle is now underway. Watersheds of interest to the three parks (with their first year in the cycle) include Gauley River (1998) and Upper New River, Lower New River, and Greenbrier River (1999).

A similar program is Watershed Assessment. Also operating on a 5-year cycle, this program collects and interprets water quality and biological information. Information gained from this program is used to determine the quality of streams in West Virginia. Streams that do not meet water quality standards for designated uses are placed on the state's list of impaired streams. This list is often called the 303(d).

Section 303(d) of the Clean Water Act requires states to develop lists of waters that are quality-limited or fail to meet State water quality standards. These lists are updated every 2 years. West Virginia's 303(d) list is divided into four themes: Primary Waterbody List; Waterbodies Impaired by Mine Drainage; Waterbodies with Biological Impairment; and

Waterbodies Impaired by Acid Rain (West Virginia Division of Environmental Protection 1999b).

West Virginia's 303(d) lists include waters within or near the three parks (West Virginia Division of Environmental Protection 1999b). On the Primary Waterbody List are Gauley River from Summersville Dam to the mouth (GARI) and Dunloup Creek from headwaters to Glen Jean (above NERI). Zinc and lead affects aquatic life in Gauley River. Aluminum affects aquatic life in Dunloup Creek. Total Maximum Daily Load (TMDL) priorities are medium and high, respectively, for these two streams. Listed as impaired by mine drainage are 19 streams in the Gauley River watershed, 7 streams in the Lower New River watershed, and 1 stream in the Upper New River watershed. Among these streams are Peters Creek (GARI), Arbuckle Creek, and tributaries to Dunloup Creek and Piney Creek (NERI). Listed as impaired by acid rain are 18 streams in the Gauley River watershed and one drainage tributary to Manns Creek (NERI). No streams in the vicinity of the parks are listed as biologically impaired.

States are required to develop TMDLs for waters on 303(d) lists. This process identifies sources and amounts of pollution, determines pollutant-loading capacities of waters, and allocates pollutant loadings to achieve water quality standards. The TMDL program provides a method for allocating loadings among both point and nonpoint sources. Until just recently, West Virginia's program only dealt with point source pollution. Creation of TMDLs allows states to effectively evaluate applications for National Pollutant Discharge Elimination System (NPDES) permits.

The TMDL development process involves five steps: 1) selecting a pollutant; 2) estimating the assimilative capacity of the waterbody; 3) estimating pollutant loadings from all sources; 4) using computer modeling with predictive analyses to determine allowable pollution loading; and 5) allocating allowable pollution to achieve water quality standards.

The West Virginia Watershed Network is an informal association of agencies and organizations that collaborate to support efforts and provide resources so local residents can successfully manage water resources. Organizations participating in the network include NPS, EPA, OSM, WVDEP, NRCS, the Canaan Valley Institute, the River Network, and the West Virginia Rivers Coalition. This informal group publishes a newsletter ("Water Net") that includes activities of watershed organizations.

The Plateau Action Network (PAN) was organized as a non-profit group in 1997. PAN is dedicated to responsible economic development and sustainable environmental management. PAN is involved in the American Heritage Rivers Initiative process. Although concerns about a proposed power line across the Meadow River motivated formation of PAN, the group is interested in a wide variety of issues.

One such issue is pollution of Wolf Creek (NERI). This pollution is caused by leaching of the Summerlee Refuse Area, a pile of imported gob at the head of the Wolf Creek watershed. This gob is acidic, and drainage from the site introduces significant amounts of acid and metals into Wolf Creek. At one time, Wolf Creek was the water supply for the town of Fayetteville. The WV DEP, through its Office of Abandoned Mine Lands and Reclamation (AMLR) reclaimed the Summerlee Refuse Area in 1996. Water quality below the refuse area was monitored by AMLR until 1998, when acid levels had dropped significantly enough to claim that reclamation was a success.

However, highly acidic water still drained from the site. At the recommendation of WV DEP, PAN initiated bimonthly water quality monitoring in the Wolf Creek watershed (Williams 1999). In 1999 OSM funded a student intern, working under the direction of PAN, to further evaluate water quality in Wolf Creek. This study documented continued acid drainage from the reclaimed gob pile, deposition of metals in wetlands downstream of the refuse area, and high concentrations of fecal coliform bacteria at two sampling sites on Wolf Creek (Myers 1999).

In 2001 a final settlement was reached with the former owner of the Summerlee Refuse Area. This settlement allocated $375,000 to Fayetteville as compensation for loss of its water supply. Another $375,000 was allocated to more effectively reclaim the gob pile and restore the ecological integrity of Wolf Creek. The WV DEP and PAN are co-trustees of these latter funds.

The Fayette County Water Resources Committee prepared a water resources plan for Fayette County describing existing public water supply systems. This plan described raw water treatment, quality, transmission, distribution, and storage and wastewater treatment. The plan was prepared in anticipation of the proposed construction of a Fayette Plateau Regional Water System by West Virginia American Water Company (Fayette County Water Resources Committee *et al.* 1997).

Other groups concerned with the water resources in or near the three parks include Midland Trail Association, Dunloup Creek Watershed Association, Greenbrier River Watershed Association (< http://www.inetone.net/greenbrier-river-watershed >), Bluestone River Conservancy, and the West Virginia Rivers Coalition (< http://www.wvrivers.org >).

DESCRIPTION OF THE HYDROLOGICAL ENVIRONMENT

PHYSIOGRAPHY

New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River are all located entirely within the Appalachian Plateaus Physiographic Province (Fenneman 1938). Rock units in this province are essentially flat lying or gently folded. Stream drainage patterns in the Appalachian Plateaus are normally dendritic (tree-shaped). Stream valleys dissect the plateaus to form the physical relief.

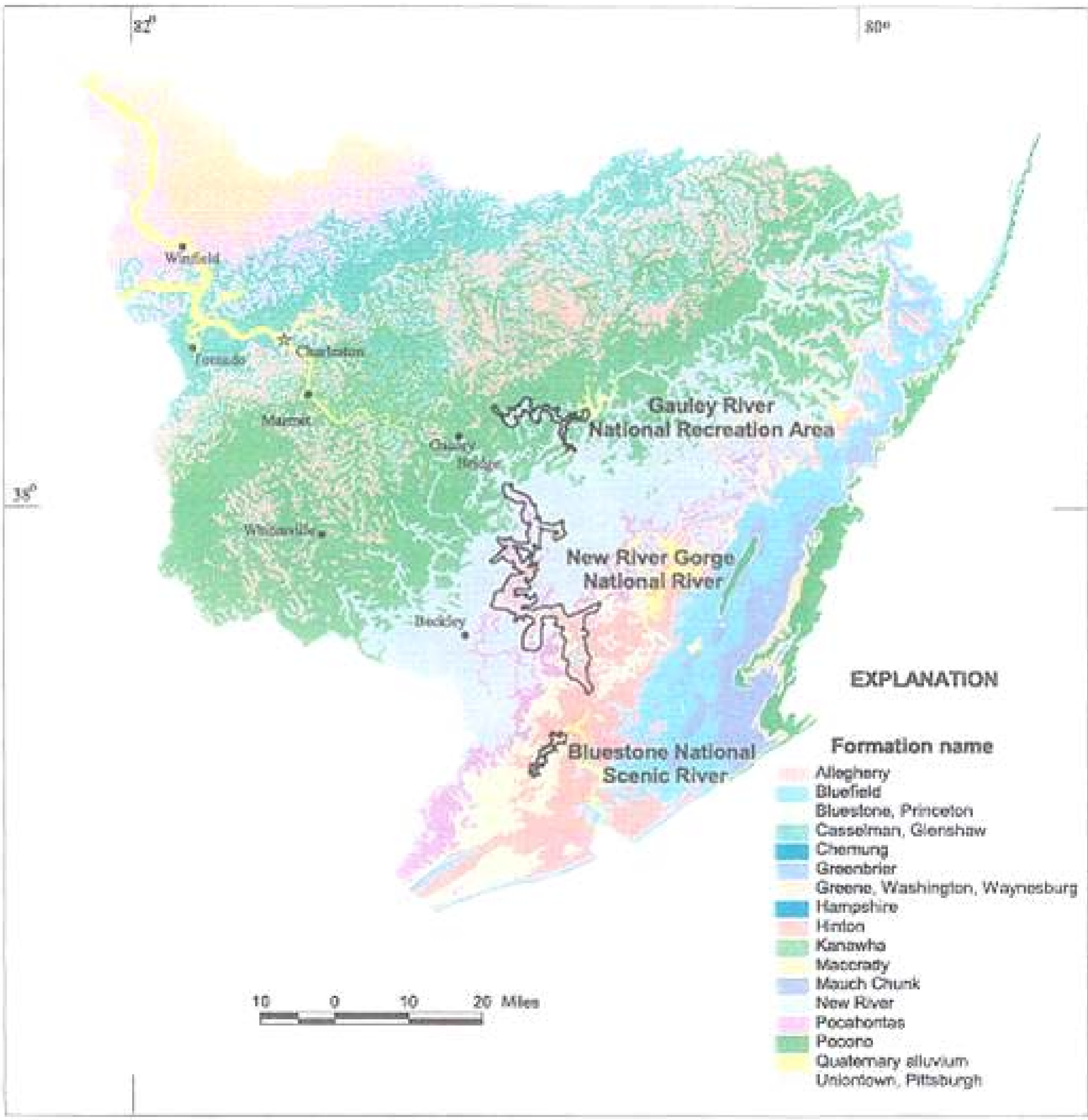
In the vicinity of the three parks, streams draining the Appalachian Plateau Province have eroded the rocks to form steep hills and deeply incised valleys. Cross sections of gorges in the three parks were evaluated using U.S. Geological Survey 1:24,000 topographic maps. The New River Gorge, based on seven cross-sections, averages 1.3 miles wide, over 1200 feet deep, and has average valley wall slopes of about 42 percent. The Gauley River Gorge at four cross sections averages about 0.7 mile wide, about 580 feet deep, and has average valley wall slopes of about 36 percent. The Bluestone River Gorge at three cross sections averages about 0.9 mile wide, about 760 feet deep, and has average valley wall slopes of about 38 percent.

GEOLOGY

All major rock units in the three parks are of sedimentary origin and of Pennsylvanian (at least 280 million years old) or Mississippian (up to 345 million years old) age. Major rock units of New River Gorge National River are the Pottsville Group (Pennsylvanian) and the Mauch Chunk Group (Mississippian). The Pottsville Group is the major rock unit of Gauley River National Recreation Area. The Mauch Chunk Group is the major rock unit of Bluestone National Scenic River.

In the New River Gorge area the Pottsville Group consists of the Kanawha, New River, and Pocahontas Formations (Figure 6). The Kanawha Formation is the youngest, and consists of 50 percent sandstone with some shale, siltstone, and coal. It is found primarily on hilltops and hillsides in the downstream end of the gorge. The New River Formation underlies the Kanawha Formation, and consists of predominantly sandstone with some shale, siltstone, and coal. It is found in the bottom of the gorge at the downstream end of the park, and on most hillsides and hilltops in the middle section of the gorge. The Pocahontas Formation underlies the New River Formation, and consists of 50 percent sandstone with some shale, siltstone, and coal. It is found in the bottom of the gorge in the middle section of the park, and on hillsides further upstream.

In New River Gorge National River the Mauch Chunk Group consists of the Bluestone, Princeton, and Hinton Formations (Figure 6). On different geologic maps these



Base from Cardwell and others, 1968, Surficial geology of West Virginia, 1:250,000

Figure 6. Geologic formations exposed on the surface near Bluestone National Scenic River, New River Gorge National River, and Gauley River Natinal Recration Area.

formations may be mapped separately, partly lumped together, or all lumped into the Mauch Chunk. These three formations all consist of red, green, and medium gray shale and sandstone, with a few limestone deposits. The Bluestone and Princeton formations that are mapped together are found along hillsides in the middle section of the gorge, and on some hilltops and higher elevations at the upper end of the gorge. The Hinton Formation is found in the bottom of the gorge at the upper end of the park, and also on hillsides and hilltops in the upper end of the basin (Ferrell 1984).

Several major geologic structures are found in the New River Gorge area. The axes of N-S trending Mann Mountain Anticline and the NE-SW trending Lawton Syncline touch the northeastern park boundary near the middle section of the gorge. The NE-SW trending Springdale Syncline and a parallel anticline cross the New River in the upper end of the gorge (Ferrell 1984).

In Gauley River National Recreation Area the Pottsville Group consists of the Kanawha and New River formations. The New River Formation is found in the bottom of the Gauley River gorge and at lower elevations in the park. The Kanawha Formation is found on hilltops and at higher elevations in the park. The Mann Mountain Anticline crosses the Gauley River at the western end of the park, and the N-S trending Enon Anticline touches the northern park boundary near the confluence of the Gauley and Meadow Rivers (McAuley 1985).

In Bluestone National Scenic River the Mauch Chunk Group consists of the Bluestone, Princeton, and Hinton formations. The Bluestone and Princeton formations are found in the valley floor and hillsides of the park, and the Hinton Formation is found at the highest elevations. The NE-SW trending Bellepoint Syncline runs parallel to and along the park, and the NE-SW trending Dunn Anticline lies just to the northwest of the Bluestone River and crosses the Little Bluestone River (Shultz 1984).

SOILS

Soil surveys have been completed for Fayette and Raleigh counties (Gorman and Espy 1975) and Mercer and Summers counties (Sponaugle *et al.* 1984). Pauley and Pauley (no date) described soils near Gauley River National Recreation Area based on Gorman and Espy (1975). An updated soil survey is currently being performed for Fayette and Raleigh Counties (Tony Jenkins, Natural Resource Conservation Service, personal communication 2001).

Ehlke *et al.* (1982, 1983) summarized the above soil surveys that include the three parks. Soils place New River Gorge National River (Dekalb-Rock outcrop) and Gauley River National Recreation Area (Dekalb-Gilpin-Enist and the Gilpin-Ernest-Buckhanon) in the Eastern Allegheny Plateau and Mountains Land Resource Area (Austin 1965, U. S. Department of Agriculture 1981). Soils in Bluestone National Scenic River (Gilpin-Dekalb) place it in the Southern Appalachian Ridges and Valleys Land Resource Area.

Based on existing published information, moderately deep silt loams or sandy loams dominate the valley bottoms and lower slopes in the three parks. These soils are well drained and very stony. Most of the soils lie on very steep (40 to 70%) slopes and are of low to moderate fertility. Derived from shale and sandstone, they are well suited for tree growth, but have severe erosion potential when destabilized. The upper slopes, ridge tops, and tributaries contain sandstone outcrops and broken cliffs that are from 1 foot to over 100 feet high. Brown sandy loams are also found on the ridge tops. The updated soil survey of these areas is expected to provide more details about these forested landscapes than was included in the older, more agronomic-oriented publications. This information is expected to be available between 2005 and 2007 (Tony Jenkins, Natural Resources Conservation Service, personal communication 2001).

VEGETATION

Vegetation in the three parks consists of dense growths of mostly deciduous trees and shrubs typical of the central hardwood forest (Strausbaugh and Core 1978). Specific community types commonly found in this region of the central hardwoods include the oak-hickory forest (Kingsley 1985) and the mixed mesophytic cove forest (Strausbaugh and Core 1978).

Steep cliffs and rock faces exposed along valley slopes of the New and Gauley Rivers contain remnant stands of old-growth trees. Massive flat lying sandstone exposed in the bottom of New River Gorge contains a unique habitat, the Appalachian River Flatrock communities. This habitat includes a large number of rare plant species (Rouse and McDonald 1986).

Common trees include red and white oaks (*Quercus rubra* and *Q. alba*), basswood (*Tilia americana*), tulip poplar (*Liriodendron tulipifera*), sugar maple (*Acer saccharum*), buckeye (*Aesculus glabra*), beech (*Fagus grandifolia*), hickories (*Carya* spp.), and hemlock (*Tsuga canadensis*). Drier sites and recently disturbed areas contain Virginia (scrub) and shortleaf pines (*Pinus virginiana* and *P. echinata*). River edges support box elder (*Acer negundo*), red and silver maples (*Acer rubrum* and *A. saccharinum*), and sycamore (*Platanus occidentalis*). Less common species include white ash (*Fraxinus americana*), cucumber magnolia (*Magnolia acuminata*), and sour gum (*Nyssa sylvatica*). Low trees and shrubs include dogwood (*Cornus florida*), redbud (*Cercis canadensis*), witch hazel (*Hamamelis virginiana*), magnolia (*Magnolia fraseri*), persimmon (*Diospyros virginiana*), and rhododendron (*Rhododendron maximum*).

CLIMATE

The climate of southern and central West Virginia is primarily continental with mild summers and cold winters. Major weather systems generally approach from the west and southwest, although cold, dry polar continental air masses approach from the north and northwest. The major source of moisture for the region is the Gulf of Mexico. Land-recycled moisture from evaporation from local land and water surfaces also affects the region.

Statewide annual precipitation for West Virginia averages 42 inches, with about 60 percent received from March through August. July is the wettest month, and the September through November peiord is the driest. Average annual precipitation for the Kanawha-New River Basin is 43.5 inches. Precipitation and temperature vary with elevation. Ridge tops and higher mountains have higher annual precipitation amounts and colder annual temperatures. The New, Gauley, and Bluestone river valleys receive less precipitation than the surrounding ridges. The greatest precipitation occurs near the eastern boundaries of the watersheds feeding these rivers.

Within the Kanawha-New River watershed, about 20.5 inches of the precipitation becomes runoff. Approximately 55 percent of this runoff occurs through ground-water discharge. The remaining 23 inches of precipitation is an estimate of evapotranspiration (Eychaner 1994).

More localized precipitation data is available for several sites near the three parks. These sites include Athens (Concord College), Beckley (National Weather Service Office, Veteran's Administration (VA) Hospital), Bluefield, Bluestone Lake, Flat Top, Hico, Oak Hill, Princeton, and Summersville Dam. Length of precipitation records at these sites range from 34 years (Summersville Dam) to 122 years (Beckley VA Hospital). Annual precipitation at these sites ranges from 36.1 inches at Bluestone Lake to 45.3 inches at Oak Hill (Ken Batty, National Weather Service, personal communication 1998). Precipitation data have also been collected at park headquarters in Glen Jean since 1993. Data are incomplete at this site for years prior to 1999.

Seven of the above sites are located at elevations greater than 2000 feet, with Flat Top located at 3335 feet. Thus, these sites are not representative of annual precipitation amounts along the rivers. The Bluestone Lake site, at 1390 feet, is more representative of annual precipitation along the New River. A rain shadow exists along the bottoms of Bluestone and New River Gorges. Annual precipitation in the gorges is probably less than 40 inches per year, while annual precipitation on surrounding ridges exceeds 40 inches per year. This orographic effect of topography on precipitation makes annual precipitation amounts highly variable within the region. Regional maps of annual precipitation are not available for this area.

All of the above sites except Glen Jean and Princeton have temperature records. Length of records ranges from 10 years (Hico) to 122 years (Beckley VA Hospital). Annual mean temperature varies from 47.9 F at Flat Top to 52.7 F at Bluestone Lake (Ken Batty, personal communication 1998).

Flooding on the New and Gauley Rivers is somewhat controlled due to streamflow regulation by Bluestone and Claytor Reservoirs. Unregulated streams, including the Greenbrier, Bluestone and Meadow Rivers, and the smaller tributaries to the New and Gauley Rivers, are more susceptible to flooding.

Climatic events that result in regional flooding are frontal systems in winter and early spring, rainfall on existing or melting snowpack in winter and early spring, and tropical cyclones (hurricanes and tropical storms) in late summer or early fall. Intense thunderstorms from late spring through the summer months can cause localized flooding on tributaries.

Precipitation quality has been monitored weekly by U.S. Geologic Survey at a National Atmospheric Deposition Program site on top of a ridge at Babcock State Park.

Precipitation pH at the site is typically less than 4.5. This is at least ten times more acidic than normal precipitation (pH of about 5.6). Low pH can impact vegetation, wetlands, lakes, and streams that are not well buffered. Major ionic constituents measured include sulfates and nitrates. These form mild sulfuric and nitric acids in the atmosphere.

ANTHROPOGENIC INFLUENCES

A number of human activities have in the past, do presently, or have the potential in the future, to influence negatively waters of the three parks. Major among these influences are human waste, impacts from resource extraction activities, development, toxic spills and releases, recreational use, and stream regulation.

Fifteen wastewater treatment plants discharge almost nine million gallons per day of treated wastewater into tributaries of the New River within New River Gorge National River. Eight wastewater treatment plants discharge almost six million gallons per day of treated wastewater into waters draining Bluestone National Scenic River. Two combined sewer overflow systems in the New River drainage and one combined sewer overflow system in the Bluestone River drainage release a combination of storm runoff and untreated sewage directly to streams during storms. Many of the remaining treatment plants experience hydraulic overloads during wet periods due to poorly designed or malfunctioning collection systems.

Other discharges to streams in the parks include waste removed from treated water, industrial effluents, and mine discharges. Nonpoint runoff from urban areas such as Beckley and from agricultural areas in the Greenbrier River drainage is another source of pollution.

There are 115 abandoned mine sites in New River Gorge National River, and 11 such sites in Gauley River National Recreation Area. Surface mining occurs adjacent to Gauley River National Recreation Area. Coal mining impacts surface water and ground water quality in the area (Ehlke *et al.* 1982, 1983). In 1991, 84 active and abandoned gas wells were inventoried within, or within a half-mile of, Gauley River National Recreation Area.

Logging has occurred in and around all three parks. Logging will continue to occur as ready-to-harvest hardwood forests and wood-processing technology will attract additional forest industries to southern West Virginia. Erosion from roads associated with logging and mineral activities has increased sedimentation of local streams.

Transportation routes such as highways and railroads have led to spills of toxic chemicals into New River. Numerous highways and railroad bridges cross the New River. A main CSX rail line runs the entire length of New River Gorge. All of these routes carry chemicals from factories in the Kanawha Valley to southern and eastern markets.

Herbicide spraying occurs along CSX rail lines. Spraying also occurs on rights of way granted to American Electric Power and other interests. These herbicides can be washed into the New River during heavy rains.

Rafters and anglers attracted to the parks also may impact park resources. Aquatic habitats are stressed by additional human waste loads and other disturbances. Demand for recreational fishing has led to the introduction of non-native fish species, and angling has led to bait-bucket dumping of other non-native species. Park operations are potential sources of stress with the additional sewage and other waste products generated by normal park operations.

Bluestone and Claytor Dams regulate stream flow in the New River. Bluestone Dam also affects flow at the mouth of the Bluestone River. Summersville Dam regulates flow of the Gauley River. These dams reduce peak flows and flooding. This could affect riparian areas, especially rare native plant communities. Bluestone and Summersville Dams are bottom-release facilities. Operation of these dams lowers downstream stream temperatures.

SURFACE WATERS

Hydrology

New River Gorge National River, Bluestone National Scenic River, and Gauley River National Recreation Area are all part of the same watershed and river system. The Bluestone River is tributary to New River. The confluence of the New and Gauley Rivers forms the Kanawha River, which flows into the Ohio River, which then flows into the Mississippi River. The greater Kanawha-New River watershed includes parts of North Carolina (756 square miles), Virginia (3,044 square miles) and West Virginia (8,424 square miles).

The New River begins at the confluence of the North and South Forks in the Blue Ridge Mountains near Blowing Rock, North Carolina. New River flows generally northward for 250 miles to Gauley Bridge, West Virginia, where the Gauley River joins it. The Kanawha River flows northwest another 97 miles before emptying into the Ohio River at Point Pleasant, West Virginia (Eychaner 1994).

The New River and the upper Kanawha River roughly follow the course of the ancestral Teays River. This watercourse, which has existed since before the Pleistocene Ice Age (about 2,000,000 to 10,000 years ago), is one reason New River is sometimes considered the oldest river in the western hemisphere (Welker 1982). Exact age of New River, and claims that it is the oldest river in North America and the second oldest river in the world, are subject to some debate. Still, New River is the only river that begins in the Blue Ridge physiographic province, and cuts northwestward across the entire long axis of the Valley and Ridge province, and well into the Appalachian Plateau province (Jenkins and Burkhead 1994).

The only major tributaries to New River above its confluence with Gauley River are the Bluestone and Greenbrier Rivers. Both of these tributaries enter New River within a few miles of each other near Hinton, West Virginia (Fig. 1). Bluestone River enters New River within Bluestone Lake, about 2½ miles above Bluestone Dam. Greenbrier River enters New River about 4 miles farther downstream, about 1½ miles downstream of Bluestone Dam.

The Greenbrier River drains 1,625 square miles. On average, it contributes about 27% of New River flow as measured at the nearest downstream gauge, New River at Hinton (Table 4). Bluestone River drains 460 square miles. Its contribution to New River flow is proportionally less. Extrapolating the data from the Bluestone River at Pipestem USGS gauge site, which is about 12½ miles above its confluence with New River, yields a mean daily flow of 544 cfs. This is almost 10% of New River flow at the confluence, and almost 7% of the flow measured at the Hinton gauge.

Table 4. New River drainage basin stream gauging station information (after Flug 1987). Locations are current or abandoned U. S. Geological Survey gauging sites. Mean values for New River sites are computed for the period 1949 to 1983 (post-construction of Bluestone Dam), except for New River at Thurmond, which is computed for the period 1981 to 2000. Mean values for other sites are computed from the beginning of the record through 2000, or the end of the record if abandoned prior to 2000 (Ward *et al.* 2000).

Location	Available Period of Record	Drainage Area (mi^2)	Mean Discharge (cfs)	Mean Annual Flow (million ac-ft)
New River				
Glen Lyn, VA	1927 – current	3768	5114	3.7
Bluestone Dam	1923 – 1983	4602	5744	4.2
Hinton	1936 – current	6256	8130	5.9
Thurmond	1981 – current	6687	8776	6.3
Greenbrier River				
Alderson	1895 – current	1364	1998	1.4
Hilldale	1936 – current	1619	2274	1.6
Bluestone River				
Pipestem	1950 – current	395	467	0.3
Gauley River				
Belva	1928 – 1999	1422	2752	2.0
Meadow River				
Mount Lookout	1966 – current	365	733	0.5

The Bluestone River originates in southwestern Virginia and flows 77 miles northeast to its confluence with New River. Bluestone National Scenic River contains 12.5 miles of Bluestone River. The upper 4½ miles of Bluestone River within the authorized boundary of Bluestone National Scenic River are within Pipestem State Park. The downstream boundary of Bluestone National Scenic River is about 2½ - 3 miles (depending on the level of Bluestone Lake) above the mouth of Bluestone River. The 462 square mile watershed is elongated in shape, and has no major tributaries. Between 1950 and 2000 average discharge of Bluestone River near Pipestem, was 467 cfs, with a maximum of 19,300 cfs and a minimum of 7.0 cfs.

The Gauley River originates in the mountains of eastern West Virginia. It flows west-southwest 107 miles through a 1,422 square mile watershed to its confluence with New River. Average daily flow for Gauley River above Belva (just below the GARI boundary) between 1928 and 1999 was 2,752 cfs, with a minimum of 3.2 cfs and a maximum of 60,900 cfs.

Along its course, the Gauley River picks up the major tributaries of Williams River, Cherry River, and Cranberry River. These rivers have their headwaters in the Monongahela National Forest. Two major tributaries enter the Gauley River within Gauley River National Recreation Area, Peters Creek and Meadow River. Only a small portion of Peters Creek is within the boundary of Gauley River National Recreation Area, while a sizable portion of the Meadow River lies within the boundary.

The Meadow River, a major tributary of Gauley River, flows through Gauley River National Recreation Area for the last almost six miles of its course. It begins above Grassy Meadows in Greenbrier County, West Virginia, at an elevation of approximately 2470 feet. It flows north and northwest approximately 62 miles to its mouth on Gauley River, at an elevation of 1180 feet. Between 1966 and 2000 the average discharge of Meadow River near its mouth was 733 cfs, with a maximum of 18,500 cfs and a minimum of 3.0 cfs (Ward *et al.* 1997).

Average gradient of the New River over its entire course is about 13 feet per mile. Within New River Gorge National River the average gradient is about 10½ feet per mile. In the lower gorge, between Cunard and Fayette Station, the average gradient of New River is 19.4 feet per mile. Average gradient of the Bluestone River over its entire course is 27 feet per mile. Within Bluestone National Scenic River the average gradient is approximately 12.4 feet per mile. Within Gauley River National Recreation Area the average gradient of Gauley River is 26 feet per mile. Average gradient of the Meadow River over its entire length is approximately 21 feet per mile. Within the Gauley River National Recreation Area the average gradient is 88 feet per mile.

Bluestone Dam, located just upstream from the boundary of New River Gorge National River, and to a lesser extent Claytor Dam located further upstream in Virginia, influence the flow regime of New River within the park. Bluestone Dam forms Bluestone Reservoir at the confluence of New and Bluestone Rivers. This dam also inundates the lower reaches of Bluestone National Scenic River. Operated by the Army Corps of Engineers (COE), Bluestone Dam generally functions as a flood control structure, and is supposedly operated on a run-of-the-river (outflow equals inflow) basis. Claytor Dam is operated by Appalachian Power (doing business as American Electric Power) on a power-peaking basis to generate electricity.

If Bluestone Dam operated on a true run-of-the-river basis, it should theoretically provide natural flows downstream. However, inflows to Bluestone Lake are influenced by operation of Claytor Lake further upstream. This causes daily and weekly fluctuations of Bluestone Lake inflow, which is reflected in the discharge from Bluestone Dam. Also, the COE attempts to maintain relatively constant summer and winter lake pools (1410 feet and 1406 feet above mean sea level, respectively) in Bluestone Lake. These factors result in an unnatural flow pattern in New River Gorge.

Flug (1987) reviewed New River flow patterns, and identified the influence of the operation of these dams, especially Bluestone Dam, on flows in New River Gorge. This analysis required knowledge of inflows to, and outflows from, Bluestone Lake. Bluestone Lake inflow can be estimated by adding the values from two USGS gauging stations. Most water entering Bluestone Lake comes from New River. This inflow is closely approximated by a gauge just upstream of the West Virginia-Virginia border (New River at Glen Lyn, VA, 03176500). Inflow from Bluestone River, the other large contributor to the lake, is closely approximated by a gauge near the upstream boundary of Bluestone National Scenic River (Bluestone River near Pipestem, WV, 03179000). Bluestone Lake outflow can be obtained by two methods. One method is Bluestone Dam release information provided by the COE. This figure is based on the number of sluice gates open at Bluestone Dam, and the hydraulic head of Bluestone Lake above the sluice gates. Discharge from Bluestone Dam can also be estimated by arithmetic treatment of data from two USGS gauges. This is done by subtracting the discharge from Greenbrier River near its mouth (Greenbrier River at Hilldale, WV, 0318400) from discharge of New River just downstream of the confluence of the Greenbrier (New River at Hinton, WV, 03184500).

Even with operation of the dams, flows in the New River system exhibit a high degree of variability. Figure 7 shows mean (average), maximum and minimum releases from Bluestone Dam between 1949 and 1983. On April 7 (day 97) discharge varied from less than 3,000 cfs (1966) to almost 63,000 cfs (1960). A few days earlier in April, minimum flows of only a few hundred cfs were recorded. The difference in magnitude between the maximum and minimum discharges illustrates the annual variability in the basin. The presence of Bluestone Dam has dampened these extreme values, otherwise higher values would be expected for the maximum discharges (Figure 8).

Mean daily hydrographs for the Glen Lyn and Bluestone Dam gauging stations are plotted (Figure 9) with a dimensionless scale (daily discharge divided by mean discharge for the entire period of record) because river flows generally increase downstream. Although the hydrographs match closely, with peaks and valleys paralleling each other, there are many discrepancies between the two gauging stations. These differences are mainly due to the flood control function of Bluestone Dam. Thus, Bluestone Dam releases do not correspond perfectly to a run-of-the-river pattern.

Other variations from the run-of-the-river pattern also occur. The above hydrographs are based upon mean daily discharge. Therefore they do not reflect flow fluctuations over a 24-hour period. Hourly variations in flow occur due to increased releases from Claytor Dam for peak power generation. These fluctuations are damped by the distance between the two dams, and by the relatively large size of Bluestone Lake.

On a larger time scale, there are seasonal differences between current Bluestone Dam releases and historic New River flows. There is a general pattern of water storage through the summer (inflow greater than outflow) and larger winter releases (outflow greater than inflow). Mean monthly flows for New River after completion of Bluestone Dam are shown in Figure 10. Mean monthly flows after the completion of Claytor Dam but before the completion of Bluestone Dam are shown in Figure 11. Comparing the two data sets illustrates the impact of Bluestone Dam operation on New River flows.

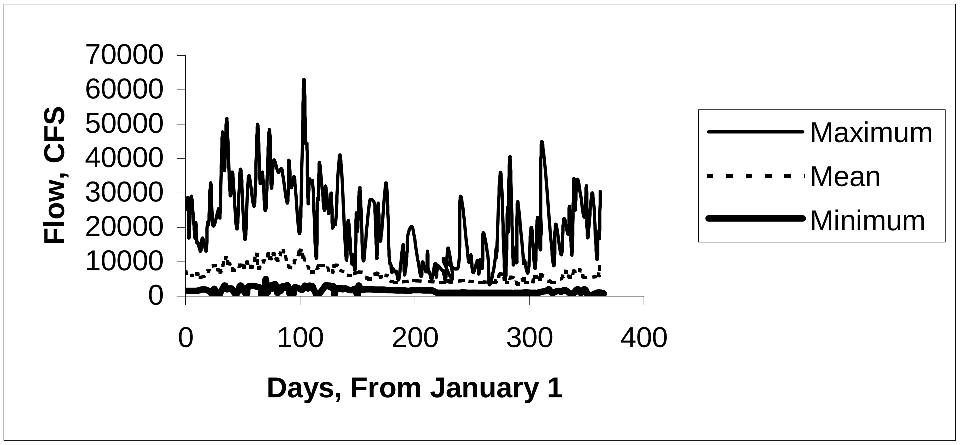


Figure 7. Maximum, minimum and mean daily Bluestone Dam releases, 1949 – 1983. After Flug (1987).

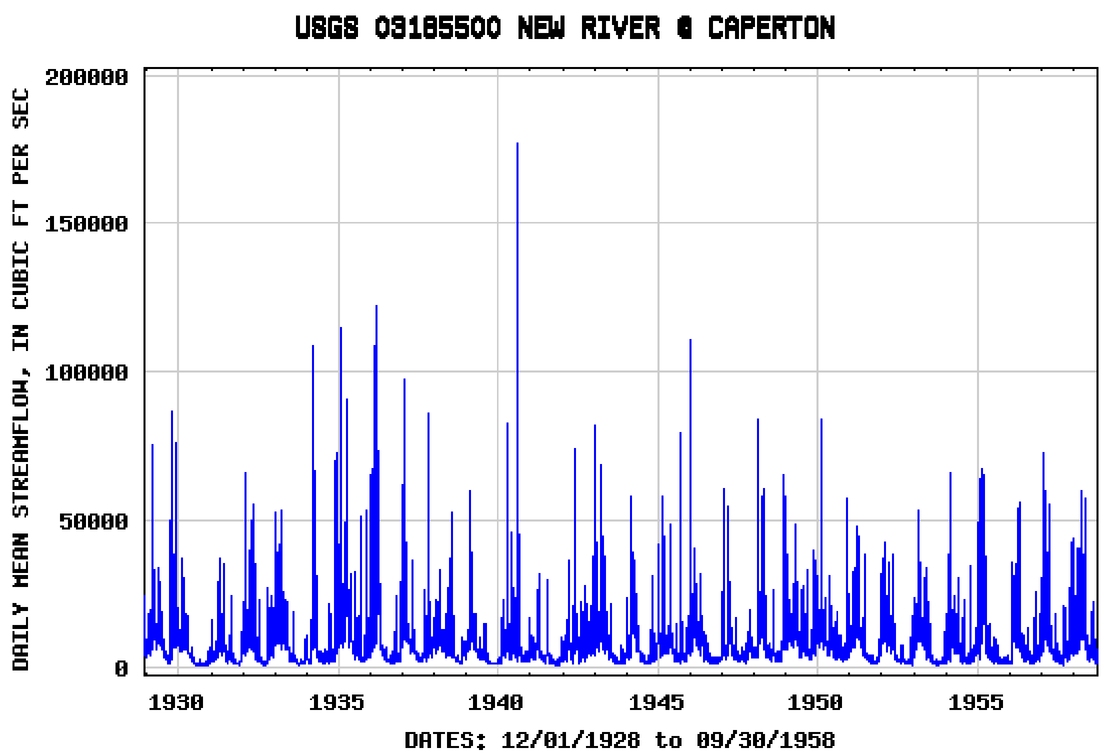


Figure 8. Daily streamflow values for New River at Caperton (03185500). After > http://www.usgs.gov > .

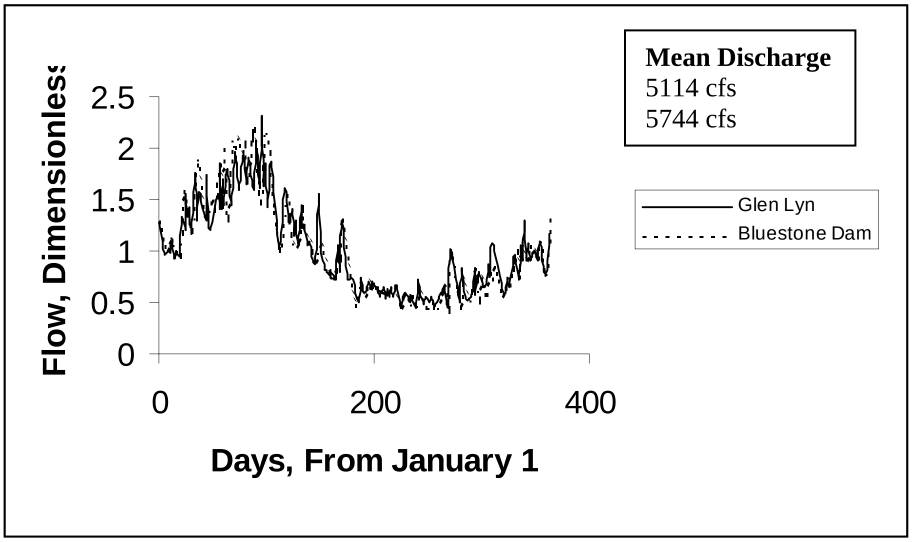


Figure 9. Mean daily dimensionless flows for the New River, 1949 – 1983. After Flug (1987).

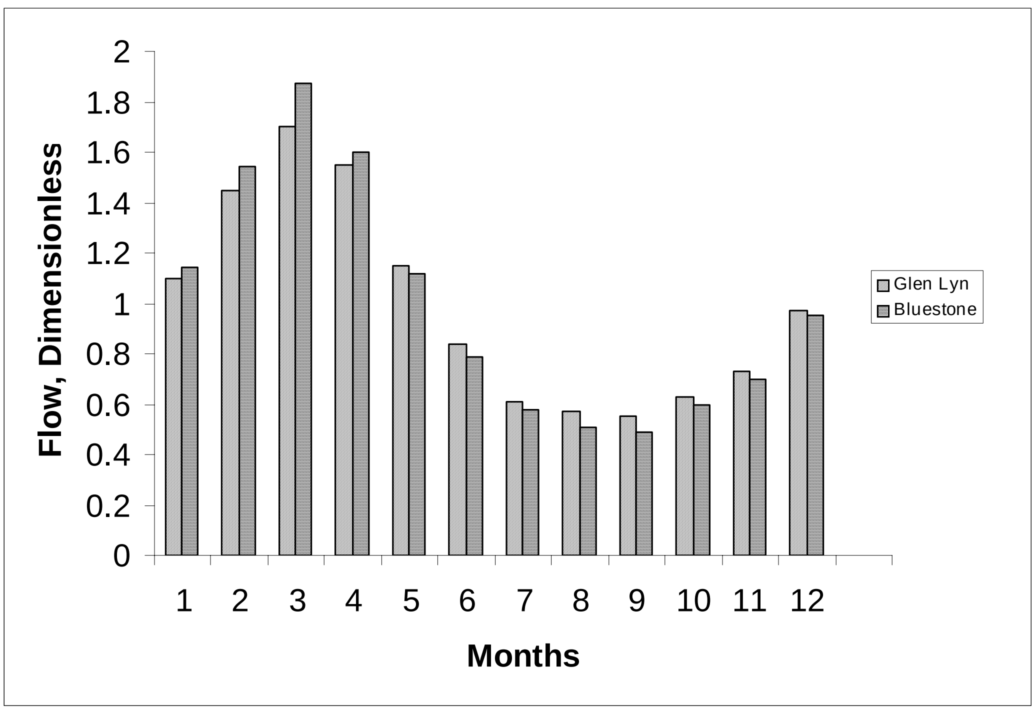


Figure 10. Mean monthly flows for the New River, 1949 – 1983, after completion of Bluestone Dam. After Flug (1987).

Although the general patterns of the two figures are similar, since completion of Bluestone Dam, mean winter flows have been greater, and mean summer flows smaller. The general pattern of higher winter runoff and lower summer runoff was evident before the completion of Claytor Dam (Figure 12). Figure 13 compares the mean daily hydrographs at Bluestone Dam for the period before and after Claytor Dam was closed. This comparison indicates that at least on a daily basis the flows discharged through Bluestone Dam appear to correspond with the natural flow pattern; there is no long-term storage of water by Claytor or Bluestone Dam.

Since 1965, Summersville Dam has regulated the flow of Gauley River within Gauley River National Recreation Area. As is the case with New River, flow regulation has dampened flow variability in Gauley River National Recreation Area (Figure 14).

The hydrograph for the unregulated Bluestone River at Pipestem is shown in Figure 15. A similar type of annual pattern would be expected for New and Gauley Rivers in the absence of (before the completion of) the dams. This pattern is also representative of all unregulated tributaries in the vicinity of the three parks.

As noted previously, the USGS operates several stream flow gauging stations in and near the three parks (Table 4). Two continuous gauges (New River at Thurmond, New River at Hinton) and eight staff gauges (near the mouths of Lick, Meadow, Piney, Laurel, Dunloup, Arbuckle, and Wolf Creeks, and Marr Branch) are located within or near New River Gorge National River. Two continuous gauges (Meadow River near Mount Lookout and Gauley River below Summersville Dam) are located within Gauley River National Recreation Area, and another (Gauley River above Belva) is located nearby. One continuous gauge (Bluestone River near Pipestem) is located within Bluestone National Scenic River.

Discharge is determined at gauges by collecting stream stage (height) data and maintaining a relationship between stage and discharge. At continuous gauges, river stage data are recorded at time intervals of one hour or less. Discharge is determined for each time interval, and mean daily discharge is computed from the time intervals. Stage-discharge relationships are maintained by frequent measurements of stream discharge using a current meter. The stage-discharge relationship is adjusted as needed based on the discharge measurements.

Stream flow statistics are summarized and published annually (e.g. Ward *et al.* 1999). These statistics can be used to estimate stream conditions for streams that are not gauged. Probabilities of the occurrence of high flows (flooding) and low flows are two common determinations developed from gauge networks and then applied to ungauged streams.

Equations for estimating peak discharges on rural, unregulated streams in West Virginia were developed by Runner (1980). This work has recently been superceded by that of Wiley *et al.* (2000). These equations (Appendix A) are not applicable to regulated streams like Gauley and New River, but are applicable to Bluestone River and to most of

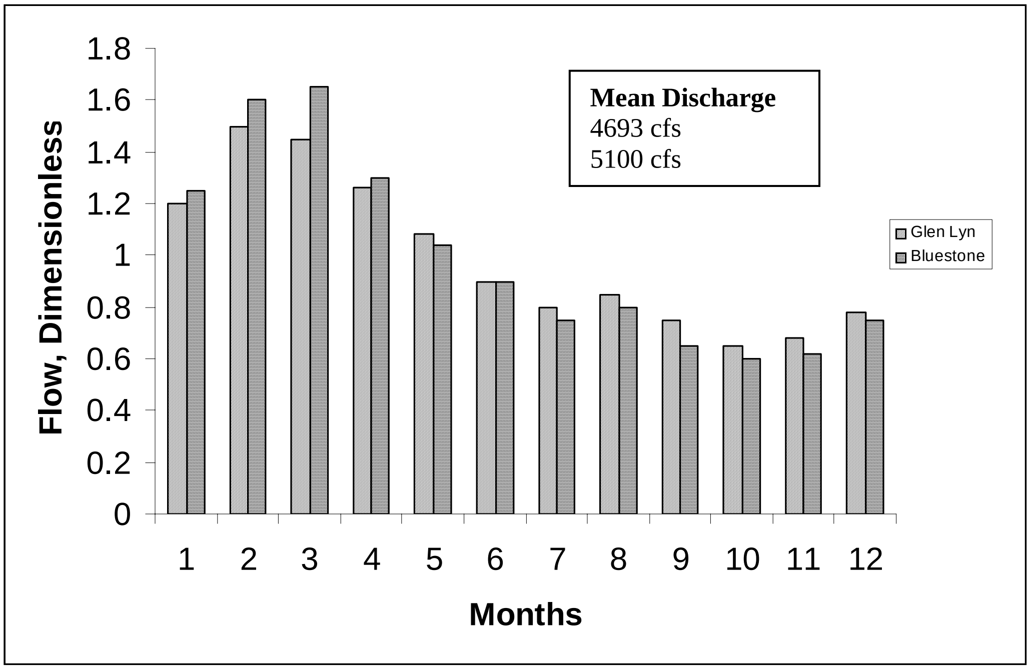


Figure 11. Mean monthly flows for the New River, 1939-1948, after completion of Claytor Dam, but before completion of Bluestone Dam. After Flug (1987).

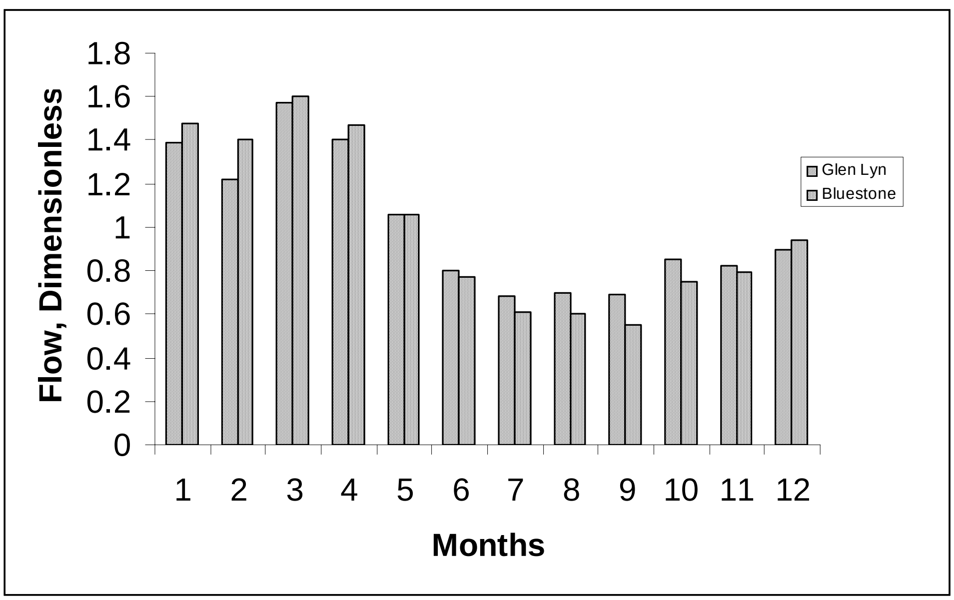


Figure 12. Mean monthly flows for the New River, pre – 1939. After Flug (1987).

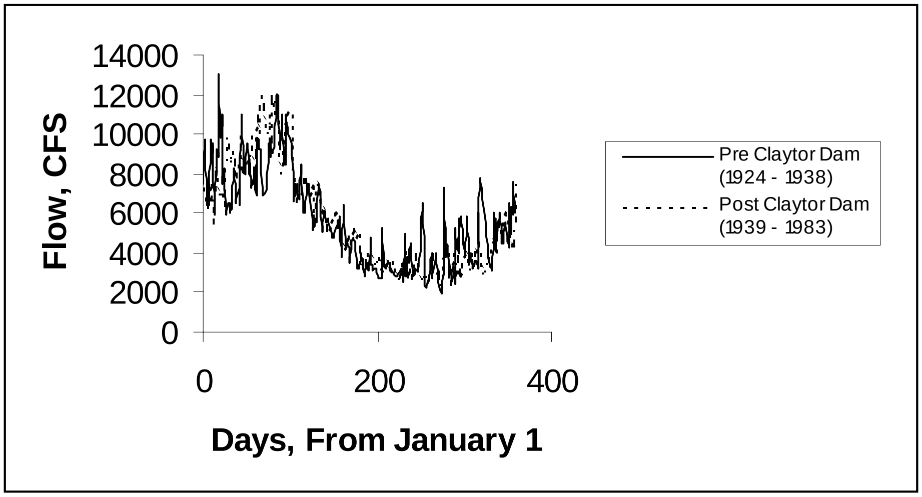


Figure 13. Mean daily Bluestone Dam flows, pre – and post – Claytor Dam. After Flug (1987).

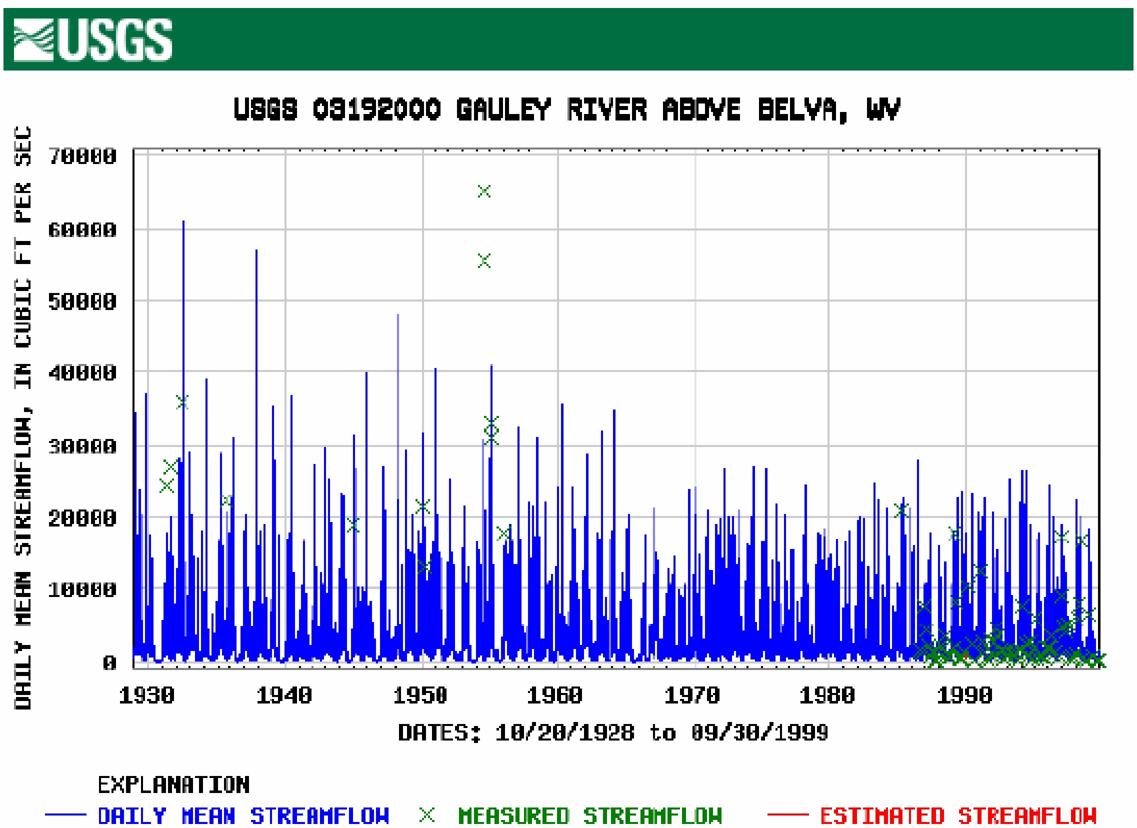


Figure 14. Daily streamflow values for Gauley River above Belva, WV (03192000). After > http://www.usgs.gov > .

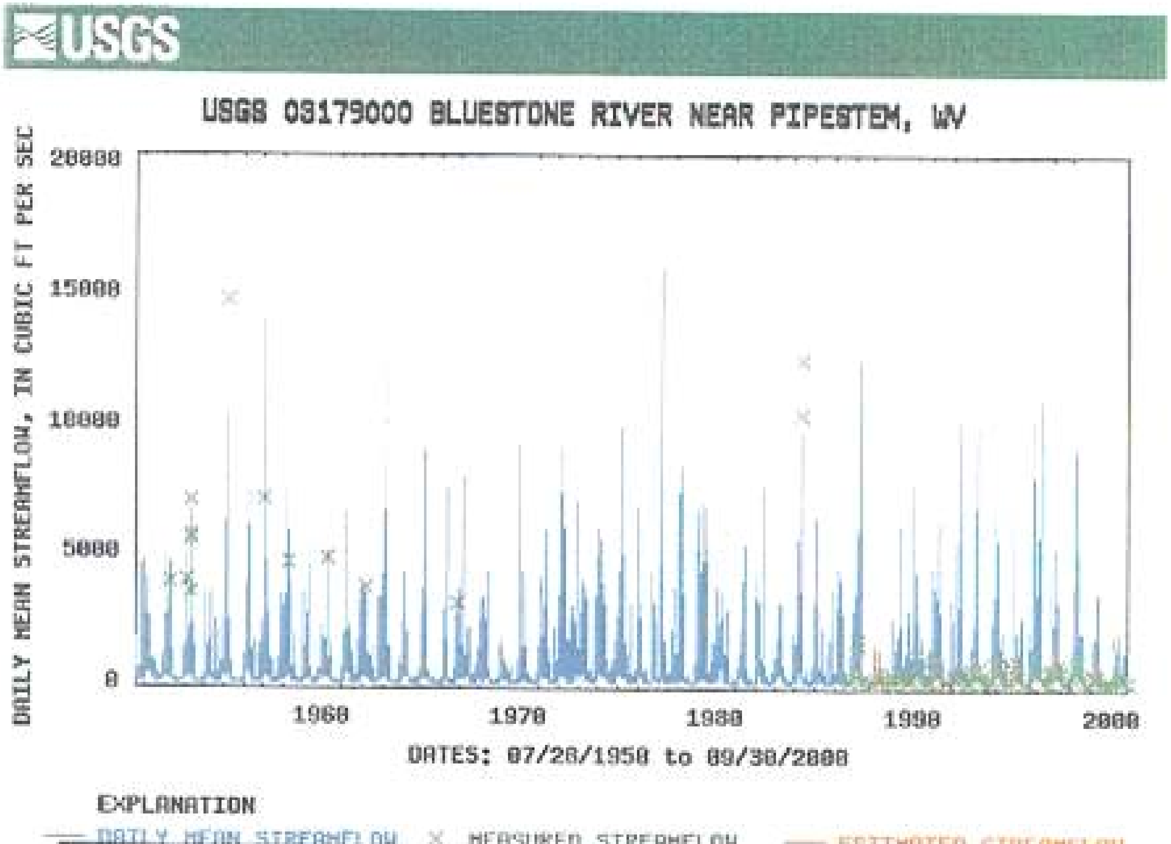


Figure 15. Daily streamflow values for Bluestone River near Pipestem, WV.
After > http://www.usgs.gov >.

the tributary streams in the three parks. Drainage area, the only input variable necessary to calculate peak discharge from these equations, was determined for many of these streams by Mathes *et al.* (1982).

Equations for estimating low flows on rural, unregulated streams were developed by Friel *et al.* (1989). These equations (Appendix B) use drainage area and a streamflow-variability index as independent variables. Estimates for the streamflow-variability index were also provided by Friel *et al.* (1989; see also figure *In Pocket*).

Water Quality

Messinger (1997) reviewed more than 300 available water quality reports that covered all of the Kanawha-New River Basin. Within the Appalachian Plateaus province, the area that contains the three parks, coal mining, improper disposal of human and animal wastes, and industrial activities were identified as affecting surface water quality.

Baseline surface water quality for New River Gorge National River was summarized from data retrieved from the U.S. Environmental Protection Agency's STORET database (National Park Service 1995a). This retrieval contained 101,426 observations of 347 parameters collected by various state and federal agencies, including the National Park Service. These observations came from 124 sites, of which 59 were located within the park. The report concluded that surface waters within the study area were impacted by bacteria and trace metals. Possible anthropogenic (human-caused) sources of contamination include residential and municipal development, wastewater discharge, active and abandoned coalmines, farming, livestock grazing, and recreational use.

A number of the parameters measured commonly had values outside their acceptable ranges. These included dissolved oxygen, pH, fecal bacteria, and several metals. Dissolved oxygen was less than 4 mg/l (EPA criterion for protection of freshwater aquatic life) in 9% of 4,898 samples. Most (94%) of these samples came from Bluestone Lake.

In 551 of 5,561 (10%) measurements, pH was outside the range of 6.5 to 9.0 standard units (EPA chronic criteria for freshwater aquatic life). Of the measurements outside the acceptable range, 479 (87%) were less than 6.5. This indicates acidic conditions, and may be due to atmospheric deposition or acid drainage, usually from coal mines. Only four total alkalinity measurements were noted, and all of these fell well below the National Park Service Air Quality Division's 200 microequivalents per liter (μeq/L) threshold that indicates sensitivity to acidic deposition.

Total coliform bacteria exceeded the National Park Service Water Resources Division bathing water criterion of 1,000 colony forming units per 100 milliliters (CFU/100 ml) in 312 out of 606 (51%) samples measured. The West Virginia standard for water-contact recreation (and National Park Service Water Resource Division standard for bathing water) of 200 CFU/100 ml of fecal coliform bacteria was exceeded in 1,020 of 2,551 (40%) of measurements.

Some metals exceeded acceptable standards (EPA criteria for freshwater aquatic life, EPA drinking water criteria, or both) in more than 10% of the samples. These included antimony (59 out of 510 samples; 12%), cadmium (147/619; 24%), lead (212/774; 27%), mercury (133/527; 25%), and thallium (30/69; 44%).

Other constituents exceeded acceptable standards less often. These included arsenic (1/248; <1%), beryllium (6/390; 2%), chromium (6/935; <1%), copper (29/503; 6%), total cyanide (1/229; <1%), fluoride (1/532; <1%), nickel (1/272; <1%), silver (11/286; 4%), sulfate (10/1,270; <1%), and zinc (36/874; 4%). Turbidity exceeded the National Park Service Water Resources Division screening criterion of 50 turbidity units (JTU, FTU, or NTU, depending on the method used) in 4% (72/1,722) of samples.

A similar report was generated for Gauley River National Recreation Area (National Park Service 1995d). Retrieved from STORET were 91,940 observations for 326 separate parameters at 80 monitoring stations, 15 of which were located within the park boundary. The report concluded that waters in and near Gauley River National Recreation Area also have been impacted by bacteria and trace metals. Potential anthropogenic sources of contamination were the same as those listed for New River Gorge National River.

Eighteen parameters indicated potential water quality problems. Significant among these were pH, coliform bacteria, and some metals.

Of 6,916 pH measurements, 3,338 (48%) were out side the range of 6.5 – 9.0 standard units. All but 3 (99.9+%) of the measurements outside this range had values less than 6.5 (acidic). Only six alkalinity measurements were included in this summary, and all of these values were well below the 200μeq/L threshold. As noted above, these values indicate acidic conditions, and sensitivity to acidic deposition.

Total coliform bacteria concentrations exceeded 1,000 CFU/100ml in 100 of 309 (32%) samples. Fecal coliform bacteria concentrations exceeded 200 CFU/100ml in 180 of 720 (25%) observations.

Four chemical constituents exceeded acceptable standards in at least 10% of the samples. These included cadmium (78/417; 19%), lead (79/588; 13%), mercury (55/466; 12%), and thallium (48/1077; 20%). Turbidity exceeded 50 turbidity units in 91 of 949 (10%) of samples.

Other constituents exceeded standards much less often. These included antimony (15/667; 2%), beryllium (5/705; <1%), chloride (1/1,136; <1%), chromium (1/693; <1%), copper (1/305; <1%), nickel (2/240; <1%), silver (3/109; 3%), and zinc (48/1077; 4%).

A third report provided similar information for Bluestone National Scenic River (National Park Service 1995e). The report summarized 23,459 observations for 188 separate parameters at 29 monitoring stations, 12 of which were within the park boundary. As for the other two parks, the report concluded that waters in the area have been impacted by bacteria and trace metals, and that the potential sources of contamination were similar.

Dissolved oxygen was less than 4mg/L in 35 of 1,543 (2%) observations. Thirty (86%) of these observations occurred in Bluestone Lake on New River.

Of 1,600 pH measurements, 99 (6%) were outside the range of 6.5 – 9.0 standard units. Of the measurements outside the acceptable range, 72 (73%) were below 6.5, indicating acidic conditions. No total alkalinity measurements were recorded.

Total coliform bacteria exceeded 1000 CFU/100ml in 56 of 101 (55%) of samples. Fecal coliform bacteria exceeded 200 CFU/100ml in 81 of 252 (32%) of samples.

Several chemical constituents exceeded acceptable standards in at least 10% of samples. These included antimony (19/136; 14%), cadmium (17/110; 15%), lead (55/167; 33%), mercury (21/102; 21%), and thallium (25/25; 100%).

Other constituents exceeded standards less often. These included beryllium (1/125; <1%), copper (3/71; 4%), total cyanide (1/41; 2%), nickel (1/51; 2%), silver (3/53; 6%), total sulfate (1/274; <1%), and zinc (15/209; 7%). Turbidity exceeded 50 turbidity units in 20 of 363 (6%) of samples.

The National Park Service has collected (or had collected), water quality data from the three parks since 1980. A brief history of this program is provided in the Water Resources Issues section (Water Quality Data Collection and Management) of this document. At present, samples are collected regularly at five sites each in Bluestone National Scenic River and Gauley River National Recreation Area and at 18 sites in New River Gorge National River. Other sites are sampled as conditions warrant.

Samples collected by NPS are primarily for enumeration of fecal coliform bacteria. NPS has analyzed some samples for *E. coli*, and some simultaneous comparison sampling for *E. coli* and fecal coliform has occurred. Other parameters measured or noted during bacterial sampling include air and water temperature, discharge, alkalinity, turbidity, pH, and dissolved oxygen.

The National Park Service data for New River Gorge National River have been analyzed and presented in a number of reports (Wood 1990a,b,c, West Virginia Department of Natural Resources 1988, 1989a, Schmidt and Hebner 1991, Hebner 1991, Gibson 1993, Sullivan 1993a,b, Wilson and Purvis 2000). In addition to Gibson (1993), Sullivan (1993b) and Wilson and Purvis (2000), National Park Service (1991) and Sullivan (1992a) cover water quality data for Bluestone National Scenic River and Gauley River National Recreation Area. These reports cover baseline data collected through 1997. A report evaluating data from the three parks for 1998 through 2000 is nearing completion. It is anticipated that annual reports will summarize data beginning with samples collected during 2001. An evaluation of long-term trends in water quality for the three parks is scheduled to begin in 2003.

Evaluation of the NPS data suggested a strong relationship between stream discharge and density of fecal coliform bacteria. To further evaluate this relationship, storm events were heavily sampled beginning in 1998. This special effort focused on Dunloup Creek (NERI), although Piney Creek (NERI) also was sampled. Dunloup Creek flows past NPS headquarters at Glen Jean, so it is easy to determine if a storm event has increased discharge. A rain gauge at headquarters provides accurate determination of storm event magnitude, and a USGS-maintained stream gauge at the sampling site about 5 miles from headquarters provides accurate determination of discharge. Sample analysis has shown that fecal coliform bacteria density does increase during storm events (Purvis and Wilson 1999). Efforts to more clearly define this relationship continue.

Severe flooding in May, and especially July of 2001 emphasized the issue of storm event water quality. Intensive sampling revealed extremely high densities of fecal coliform bacteria in a number of streams (Vandersall and Purvis, *in prep*). The park issued a health advisory, and briefed the commercial outfitting industry and the West Virginia Division of Tourism about the matter. Concern about this issue, and its potential effects on human health and the area's tourist industry led to inclusion of a storm event water quality monitoring proposal in the flood rehabilitation plan (Resource Assessment Team 2001). This proposal was funded in 2002 for one year.

Beginning in 1996, water quality data were collected in the Kanawha-New River Basin study unit of the USGS National Water Quality Assessment (NAWQA) program. Physical, chemical, and biological data collected for this program are presented in Ward *et al.* (1997,1998,1999). The major findings of this program are summarized in Paybins *et al.* (2000). Other interpretive reports include Messinger (1997), Messinger and Hughes (2000), Kozar *et al.* (2000), Chambers and Messinger (2001), and Messinger and

Chambers (2001). Due to changes in program priorities, the USGS decided not to fund the Kanawha-New River Basin study unit after Fiscal Year 2001 (Doug Chambers, U.S. Geological Survey, personal communication 2002). Some aspects of this program that are relevant to the three parks are presented below.

Data collected from New River at Thurmond (within New River Gorge National River) indicate the water is alkaline and typically soft, but may be moderately hard. Alkalinity is low to moderate. Thus the river is at best moderately buffered against acid inputs. Fecal coliform bacteria exceeded 200 colonies per 100 milliliters (the standard for water contact recreation) in some samples.

Data collected from Dunloup Creek at Harvey (within NERI) during 1994 and 1995 indicate alkaline water that is typically hard, with a moderately high alkalinity. Fecal coliform concentrations commonly exceeded 200 colonies per 100 milliliters.

Peters Creek joins Gauley River within Gauley River National Recreation Area. The Peters Creek at Lockwood site is just upstream from the park boundary. Data indicate water at this site is alkaline and moderately hard. Alkalinity is low. Thus the stream is not well buffered against acid inputs. This condition is typical of many streams and rivers in the Gauley River watershed. Fecal coliform bacteria concentrations commonly exceed 200 colonies per 100 milliliters. Concentrations of *E. coli*, considered to be a good indicator of health risks, were also fairly high.

The Bluestone River at Spanishburg site is several miles upstream from the Bluestone National Scenic River boundary. Water at this site is alkaline and typically moderately hard. Thus it is moderately buffered against acid inputs. Fecal coliform bacteria concentrations exceed 200 colonies per 100 milliliters in some samples, and some *E. coli* samples were high.

Part of the NAWQA program documented the occurrence of contaminants (persistent organic compounds and trace elements) in streambed sediments and fish tissues. For this study, sampling sites particularly relevant to the three parks include Bluestone River at Spanishburg (BLUE), Bluestone River near Pipestem (BLUE), New River at Hinton (NERI), Piney Creek near McCreery (NERI), New River at Thurmond (NERI), Meadow River near Mt. Lookout (GARI), and Peters Creek near Lockwood (GARI). This study found nickel, lead, and several polycyclic aromatic hydrocarbons (PAHs, derived from coal) in streambed sediments at some sites in concentrations thought to be harmful to aquatic life (Messinger and Chambers 1998). Concern about the concentrations noted for PAHs led the National Park Service to fund the U. S. Geological Survey in 2002 to further study this matter. Sediment concentrations of most metals, polychlorinated biphenyls (PCBs), and pesticides and pesticide residues were low.

Concentrations of mercury in rock bass (*Ambloplites rupestris*) livers collected at high-elevation sites in the Gauley River Basin (above GARI) were the highest measured in the Kanawha River Basin (Chambers and Messinger 1998). These values were near thresholds used as guidance for consumption advisories for edible portions of fish. Livers of fish are generally not consumed. Livers concentrate metals more efficiently than do muscles (the part generally consumed), so comparing liver data to edible portion standards should be used only as a first reference, and interpreted cautiously.

Concentrations of other constituents were generally low relative to consumption advisory guidance. Reports evaluating nutrients and bacteria, organic compounds, and the relations between both benthic invertebrate communities (Chambers and Messinger 2001) and fish communities (Messinger and Chambers 2001) with selected environmental variables have been published.

Under section 303(d) of the Clean Water Act (CWA), each state is mandated to develop and submit to EPA on a periodic basis a list of water quality limited waters. Federal law also mandates states to develop Total Maximum Daily Loads (TMDLs) for waters that are water quality limited. In its most simple terms, a TMDL is a plan of action that is used to clean up polluted waters.

The 1998 West Virginia 303(d) lists describe several types of impaired waters. The Primary Waterbody List includes the state's waters that are being actively considered for TMDL development. A second list includes streams that are impaired by mine drainage. A third list includes waterbodies with biological impairment. The fourth list includes waterbodies that are impaired by acid rain.

The Primary Waterbody List includes the entire length of Gauley River within Gauley River National Recreation Area. This reach is listed as being impaired by lead and zinc from an undetermined source. Also on this list is Dunloup Creek for its entire length within New River Gorge National River. This stream is listed as being impaired by aluminum from an undetermined source.

The list of Waterbodies Impaired by Mine Drainage includes 19 streams in the Gauley River drainage. This includes the entire length of Peters Creek within Gauley River National Recreation Area. Four streams in New River Gorge National River are also included on this list. These streams are Meadow Fork of Dunloup Creek (the site of the mine drainage is right at the park boundary), Arbuckle Creek, Batoff Creek, and a tributary of Piney Creek.

No streams within or tributary to the three parks are included on the list of Waterbodies with Biological Impairment. This is probably due to the fact that the Watershed Assessment Program of the West Virginia Division of Environmental Protection has been evaluating streams throughout the state on a 5-year rotation. Streams in, and draining into, the three parks, were included in the 2002 update of this list.

Eighteen streams in the Gauley River drainage are included on the list of Waterbodies Impaired by Acid Rain. All of these streams are in the upper reaches of the watershed, and well above Summersville Lake.

As note above, the West Virginia Division of Environmental Protection is presently working on the next round of 303(d) lists. These lists may be expanded to include waters that are impaired by non-point source pollution and fecal bacteria. If this is the case, many more streams in and tributary to the three parks may appear on these lists.

The West Virginia Division of Environmental Protection lists toxic releases to streams in its online computer watershed databases in land use statistics tables (West Virginia Division of Environmental Protection 1999a). No toxic releases are listed for the period 1987-96 for the Gauley River, Lower New River, or Upper New River watersheds.

The U. S. Environmental Protection Agency is in the process of determining the ecological health of the United States. One part of this process is the Environmental Monitoring and Assessment Program (EMAP). West Virginia and four other states are included in Mid-Atlantic Highlands Stream Assessment portion of EMAP. The program was designed to assess the general condition of streams across the region. This was accomplished by measuring a suite of ecosystem condition indicators at a probability-based sample of 500 sites on small streams across the study area. This effort began in 1993, and the final report was published in 2000 (Environmental Monitoring and Assessment Program 2000).

Biological indicators evaluated were fish, benthic macroinvertebrate, and periphyton assemblages, and sediment microbial respiration. Fish tissue contaminants also were noted. Water quality measurements included nutrients, suspended sediments, cations, anions, pH, acid neutralizing capacity, water temperature, and dissolved oxygen. Stream physical habitat, riparian habitat, land cover, road density, human population density, ecoregions, geology, and fish stocking and management practices were also documented.

The EMAP program noted a number of water quality issues in the region. These included ecological conditions of fish and aquatic insects, habitat stressors such as channel sedimentation and riparian streambank alteration, mine drainage, acid rain, nutrients, contaminants, and non-native species.

The EMAP study evaluated the above water quality issues in three geographic patterns: states, watersheds, and ecoregions. For the area of each geographic pattern that included the three parks, several trends were noted. Ecological conditions of fish and aquatic insects were towards the high end of the range in terms of percentage of stream miles that were ranked as poor. Channel sedimentation was not as severe as in other areas, but riparian alteration was high. Mine drainage and acid rain problems were high, but nutrient problems were low. Fish contamination was variable, and inspection of the actual data will be required to narrow this issue down. Problems with non-native species were also high in the regions including the three parks.

GROUND WATER

Hydrogeology

Precipitation is the major source of ground water in the three parks. The amount of precipitation recharging ground-water reservoirs is affected by vegetation, ground slope, soil cover, geology, and climatic conditions (Fetter 1980). Only a small portion of falling precipitation actually enters the ground-water system. Processes such as overland runoff, interception by vegetation, and evapotranspiration direct most precipitation into the surface water or atmospheric phases of the water cycle. Water that percolates through the soil eventually reaches a zone of saturation, the ground-water reservoir. Annual runoff in southern West Virginia (including New River Gorge National River and Bluestone National Scenic River) is about 16 inches (Appel 1986). Values for Gauley River National Recreation Area may be higher. Annual runoff in mountainous eastern West Virginia is about 40 inches per year (Appel 1986). Ground water recharge is estimated to be 2 to 6 inches per year in noncarbonate, consolidated-rock areas of West Virginia. This includes all three parks. Differences in rock permeability and structural attitude affect ground-water flow (Fetter 1980). Velocity of ground water flow in most rocks is low, ranging from a few inches to several hundred feet per year. Flow velocity is controlled by hydraulic gradient (slope of the water table or potentiometric surface), and permeability (ability of rocks to transmit water).

Two types of rock openings, intergranular openings and fractures, determine the degree of permeability. Intergranular openings were formed when the rock materials were deposited, compacted, and cemented. They tend to be larger and more important in coarse-grained rocks such as sandstone than in fine-grained rocks such as shale, limestone, and clay. The actual permeability of the rock is determined by the degree of interconnection of the intergranular openings. Fractures, including faults, joints, and bedding-plane separations, are the main pathways for groundwater flow in the consolidated clastic sedimentary rocks of the Appalachian Plateaus Province. Hence these types of openings are most important in the three parks (Ferrell 1984).

Stress relief fractures occur in response to the unloading effect caused by the erosion of valleys (Wyrick and Borchers 1981). Stress-relief fractures are local and confined to valley sides and bottoms. They significantly affect the occurrence and flow of ground water in the parks (Ferrell 1984). High topographic areas or ridges function as recharge areas. Water infiltrates the surface and flows downward and laterally through fractures in shallow bedrock. The rate of ground water flow per unit area (hydraulic conductivity) decreases with increasing depth. Thus ground water flows primarily in a lateral direction along fractures or bedding planes, or through nearly horizontal coal seams that can have high permeability even at depth. If the vertical rate of flow or vertical hydraulic conductivity is negligible, then ground water continues to flow laterally, discharging as springs or seeps on hillsides. Where vertical conductivity is appreciable due the stress relief fractures along valley walls or hillsides, ground-water flow follows a stair-step path through the fractures, bedding planes, and coal seams, eventually discharging to streams and (or) recharging coal seams at depth (Harlow and LeCain 1991).

In the area of the parks, ground water is obtained from wells, springs, and abandoned coalmines. Wells drilled into consolidated rock units typically have only the top few feet of the hole cased, with the remainder left as an open borehole. Ground water enters wells from one or more water bearing zones or sets of fractures. Well yields vary, depending on factors including geology and topographic setting. Within a given rock unit, well yields may vary because of localized fractures due to such factors as stress relief, structural deformation, and subsidence caused by underground mining. Well yields are greater near the axes of anticlines where fractures have been formed during the folding of the original flat lying sedimentary deposits. Well yields are less along the axes of synclines where compression has tightly compacted rock units. Well yields are typically less in areas where subsidence has occurred due to collapsed roofs of underlying coalmines. Such collapse and subsidence creates vertical fractures that facilitate downward movement of water from overlying rock units to underlying mine shafts. If these underlying mine shafts become flooded, then wells drilled into them can have high yields (Ferrell 1984). In the vicinity of New River Gorge National River the Pottsville Group has moderate to high potential to supply adequate water for industrial or public use. The Mauch Chunk Group has low to moderate potential, except in localized areas with highly fractured rock. Well yields are generally adequate for farm or domestic use (Ferrell 1984).

In the Gauley River National Recreation Area, the Kanawha and New River formations have low potential to supply yields adequate for industrial or public supply, except at only the most favorable sites where all conditions are optimized. Yields for domestic and farm use from these formations are generally adequate, except in some hillside and hilltop locations. Mining in some areas will decrease the potential for any development (McAuley 1985).

In the Bluestone National Scenic River area, the Mauch Chunk Group has high potential to yield moderate amounts of water from valley wells several hundred feet deep and from wells near anticlinal axes. Yields from these wells are adequate for domestic, farm, and small municipal and industrial use. Wells on hillsides and hilltops may not have adequate yields for any use (Shultz 1984).

Water Quality

Chemical quality of ground water is determined by the types and concentrations of minerals it contains. The types and concentrations of minerals present in ground water depend on the chemistry of the water that recharges the aquifer, the chemical and physical properties of the soil and rock through which the water moves, and the amount of time the water is in the ground-water system. Generally, water becomes more mineralized as it moves through the flow system. Water at depth moves slowly and typically is highly mineralized (Heath 1983). Ground water quality can be degraded by industrial-waste disposal, coal mining, oil and gas drilling, agricultural activities, domestic or municipal waste disposal, transportation, and rural development (Kozar and Brown 1995).

Messinger (1997) concluded that coal mining, improper disposal of human and animal wastes, and upward flow of deep, saline ground water into shallow, freshwater aquifers had affected ground-water quality in this area.

In much of West Virginia, including the three parks, topography influences the shallow ground water flow path and the chemical composition of ground water. Although recharge occurs at all topographic settings, the flow of ground water typically is towards valleys, resulting in the youngest ground water being from hilltop wells and the oldest ground water being from valley wells. Because of the chemical changes that occur as ground water percolates downward into valleys or flows laterally to hillside seeps and springs, the chemical composition of ground water tends to differ with respect to topography. Because of the differences with respect to topography, the chemical quality of water in the bedrock aquifers in the parks cannot be easily mapped. Wells in one topographic setting may yield water of a chemical quality very different from water in nearby wells in another topographic setting.

Three chemical constituents or properties that occur in ground water in the parks that vary with respect to topography are dissolved iron, dissolved manganese, and hardness (Ferrell 1988). Dissolved iron and manganese concentrations are generally greater in ground water from valley settings than in ground water from hilltop settings. High levels of iron and manganese can stain plumbing fixtures and laundry. Hardness is generally greater in ground water from hilltop settings.

Ground water from both the Pottsville Group and the Mauch Chunk Group is typically moderately hard in the vicinity of New River Gorge National River. High concentrations of iron and manganese can occur in ground water from the Pottsville, especially in valley wells of shallow depth (Ferrell 1984). Ground water from the Kanawha and New River formations is typically soft in the vicinity of Gauley River National Recreation Area, but can have high concentrations of iron and manganese, especially in valley wells of shallow depth (McAuley 1985). Ground water from the Mauch Chunk Group in the vicinity of Bluestone National Scenic River is typically moderately to very hard with relatively high concentrations of iron and manganese (Shultz 1984).

In 1997 the USGS NAWQA program studied ground water quality in randomly selected, recently constructed domestic wells in the Appalachian Plateaus Physiographic Province of West Virginia. In 1998, about 30 recently constructed domestic wells in the Appalachian Plateaus down gradient from surface coal mines that had been operated and reclaimed in compliance with the Surface Mining Control and Reclamation Act of 1977 were studied. Collection and analysis methods were the same for both studies (Koterba *et al.* 1995). Analytes included major ions, trace elements, nutrients, pesticides, volatile organic compounds, fecal indicator bacteria, and chlorofluorocarbons.

While all data from these studies have been published (Ward *et al.* 1998, 1999), analyses have been completed for only a few subjects. Age of ground water for 25 randomly sampled wells in the Appalachian Plateaus of the Kanawha-New River drainage were 13, 29, and 42 years, respectively, for hilltop, hillside, and valley wells (Kozar 1998). Radon concentrations exceeded the U.S. EPA proposed maximum contaminant level of 300 picocuries per liter for water in 15 of 30 (50 percent) wells sampled in the Appalachian Plateau (Kozar and Sheets 1997). Bacterial contamination of ground water has been thought to be a significant problem in the Kanawha-New River basin. However, analyses of water samples from 59 recently constructed wells located in fractured bedrock settings within the Appalachian Plateau and Blue Ridge Physiographic Provinces showed such contamination is rare (Sheets and Kozar 1997).

WATER RIGHTS

Like most water abundant states in the eastern United States, the right to use water in West Virginia is governed by the English common-law doctrine of riparian rights. A riparian water right arises as an incidence of property ownership. Riparian rights attach to land which is crossed by or borders a surface watercourse or which overlays underground waters from wells or springs (McGinley 1991). By virtue of its ownership of land adjacent to the Gauley, New, and Bluestone rivers, the National Park Service is a riparian landowner. As such, it enjoys the same rights to the use of water as any other riparian landowner along those rivers. The National Park Service also has riparian rights to subsurface water directly underlying its land.

West Virginia courts have established "reasonable use" of water as the guiding principle in water rights analysis. This principle allows a riparian landowner to use adjacent or underlying waters as long as it does not interfere with the reasonable uses of other riparian owners. While "reasonable use" applies equally to both ground and surface-water, the courts have also established that a riparian right to groundwater includes the requirement that groundwater be beneficially used (McGinley 1991).

Due to increasing demand for water in the eastern United States, many eastern states have adopted a form of regulated riparian rights, requiring major water users to obtain permits for their water use (Sherk 1990). With one minor exception, the West Virginia legislature has resisted all attempts at instituting this form of water-use regulation (Wright 1990). In 1994 West Virginia enacted the little known Natural Streams Preservation Act (WV Code §22-13-1 et. seq.). This act requires a permit be obtained prior to any modification, including diversion, of a "protected stream". To date, the West Virginia legislature has designated five stream reaches as protected, including "New River from its confluence with the Gauley River to its confluence with the Greenbrier River" (WV Code §22-13-5). This reach includes the entire length of New River within New River Gorge National River.

In addition to riparian water rights based on state law, the parks may also be entitled to water rights under federal law. The federal reserved water rights doctrine has become well established in public lands states, primarily in the western United States, through numerous U.S. Supreme Court decisions (e.g. Arizona *v*. California). In general, this doctrine holds that when the United States sets aside land for specific purposes it either implicitly or explicitly reserves sufficient water to meet those purposes. By virtue of its designation under the Wild and Scenic Rivers Act, Bluestone National Scenic River is entitled to a federal reserved water right sufficient to maintain the "scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values" and preserve its "free-flowing condition" (PL 90-542, as amended). Similarly, Gauley River National Recreation Area and New River Gorge National River are entitled to federal reserved water rights in sufficient quantity to meet the purposes of their respective enabling legislation. While federal reserved water rights have been incorporated into the appropriative water right systems of western states, it is unclear how reserved rights would interact with the riparian rights system of West Virginia.

Many rivers that flow through multiple states have interstate compacts allocating water among the states and in some instances establishing a regulatory entity for the entire river basin. Both New River and Bluestone River flow through multiple states. However, due to the relatively abundant water supply there is currently no interstate compact allocating the water of New River between North Carolina, Virginia, and West Virginia. Similarly, there is no interstate compact for Bluestone River between Virginia and West Virginia. Increasing water demands may eventually necessitate interstate compacts.

AQUATIC BIOLOGICAL RESOURCES

Flora

Rutherford (2000) described periphyton assemblages in tributaries to New River within New River Gorge National River. The study identified 106 species of algae, mostly diatoms, from 10 New River tributaries over a one-year sampling period. The study also described seasonal variation in periphyton community composition of the streams. Comparisons between streams showed that communities in Arbuckle and Dunloup Creeks were most similar. High abundances and frequencies of occurrence of *Schizothrix calcicola* indicated human waste to be a major contributor to pollution in many of these streams.

Diatoms also were found to be a useful indicator of water quality in streams at Indiana Dunes National Lake Shore (Stewart *et al.* 1999). This research revealed that diatom species diversity was most variable in disturbed areas with poorer water quality. Diatom species diversity was correlated with land use and three water quality factors: total alkalinity, total hardness, and specific conductance.

No published surveys have examined the occurrence, distribution, or ecology of periphyton or other algae in Bluestone National Scenic River or Gauley River National Recreation Area (Pauley and Pauley undated *a*, undated *b*). McNeill (1948) completed a statewide survey of algae. In 1997 the USGS NAWQA program collected quantitative and qualitative periphyton samples from three sites in or near the parks. These sites were Bluestone River at Spanishburg (above BLUE), New River at Thurmond (within NERI), and Peters Creek near Lockwood (above GARI). These samples have been identified and counted, but the data has not yet been published (Terry Messinger, U.S Geological Survey, personal communication, 2001). Rodgers (1977) examined periphyton communities in New River at Glen Lyn, Virginia, just upstream of the West Virginia border. Lorenz (1975), Hopkin (1976), U.S. Army Corps of Engineers (1985a), and Simmons *et al.* (1987) described phytoplankton in Bluestone and Summersville lakes. Because of habitat differences (currents, substrate, temperature, depth, light, nutrient supply, etc.) the algal communities of lakes are usually quite different from those found in adjacent streams (Hynes 1970, Cole 1975).

Buhlmann and Vaughn (1985) and Buhlman (1990) described common aquatic plants of New River Gorge National River. Emergent aquatic plants include water willow (*Justicia americana*), arrowhead (*Sagittaria* sp.), pickerel weed (*Pondelaria cordata*), and lizard tail (*Sauruus cernuus*). Submerged aquatic plants include riverweed (*Podostemum ceratophyllum*), curly pondweed (*Potamogeton crispus*), elodea (*Elodea canadensis*), wild celery (*Vallisneria americana*), water stargrass (*Heteranthera dubia*) and slender naiad (*Najas minor*). Strausbaugh and Core (1978) provided distribution information, by county, for all vascular plants, including aquatic ones, of West Virginia, along with species descriptions and a key.

Water willow, riverweed, elodea, and curly pondweed are the most commonly observed aquatic plants in New River within New River Gorge National River. Beds of water-willow are common along the margins of New River. Riverweed is common on relatively stable substrates such as large cobbles, boulders and bedrock in areas shallow enough to allow sufficient light penetration for growth. Clumps of elodea have been observed in New River. The size of these beds has increased in recent years. Whether this increase is a long-term trend, or merely the increasing phase of natural variation, is unknown. Following the floods of July 2001 some previously noted large clumps of elodea had disappeared. Curly pondweed forms dense beds along the east edge of New River outside the park just below Bluestone Dam. Benthic macroinvertebrates are collected from *Podostemum* and *Justicia* habitats, and fish are collected from *Justicia* beds during the NPS' annual long term monitoring of New River (see below). Little observational data or collections exist for Bluestone or Gauley River, or for tributaries of New, Bluestone, or Gauley River.

Several studies have examined aquatic macrophytes in the New River in Virginia (upstream of New River Gorge National River). Hill (1981) and Hill and Webster (1983), working above Claytor Lake, found that aquatic macrophytes provided an important short-term pulse of organic matter. This occurred when the plants, mostly *J. americana*, *P. ceratophyllum*, and *P. crispus*, died, after which they decomposed rapidly. Rodgers *et al.* (1983) looked at some of the same issues in New River at Glen Lyn. This pulse formed an important link between spring-summer periphyton production and fall-winter inputs of leaves from deciduous trees. Allochthonous (originating outside the stream channel; Lincoln *et al.* 1982) leaf inputs are more important in smaller streams than in larger rivers (Vannote *et al.* 1980). However, much of this organic matter that enters in the smaller tributaries does get transported into larger rivers (Newbern *et al.* 1981).

Some insects, fish, mammals, birds, and reptiles are known to consume aquatic macrophytes, but studies in New River have shown little consumption of these plants during the growing season (Rodgers *et al.* 1983). During these summer months the aquatic macrophytes major interaction with aquatic fauna appears to be that of providing vertical habitat complexity, refugia, and breeding sites. Only upon death and senescence does the majority of organic matter in these aquatic plants become available to riverine food webs.

Fauna

A great deal is known about the fauna of New River Gorge. The main channel of New River has been particularly well sampled for fish and invertebrates, although much of the fish survey data has not been published (see **Historical Fisheries Data Mining** under **Recommended Actions**). Some surveys of terrestrial vertebrates have included animals other than fish that live, feed, or reproduce in water. These include amphibians, some reptiles (particularly turtles and some snakes), some mammals (e.g. beaver, muskrat, mink, otter), and some birds (e.g. ducks and geese, wading birds, kingfisher). Substantially less information is available to describe the fauna of New River Gorge tributaries, and Bluestone and Gauley rivers.

Fish

The New River drainage, including Gauley River and its tributaries, has a native fish fauna (Table 5) that is distinct from those of the rest of the Ohio River system (Jenkins and Burkhead 1994). This unique native fauna is composed of relatively few species, with a high proportion of these native species being endemic (species with their native range restricted to a certain geographic area; Lincoln *et al.* 1982). New River above Kanawha Falls has only 46 native species. This is the lowest number of native species, and the lowest ratio of native species to drainage area, among 26 drainage systems in the eastern United States (Sheldon 1988), and is far lower than the number of native species found in adjacent river systems (Jenkins and Burkhead 1994). For example, the Kanawha River below Kanawha Falls has 90 native species. Also, there are eight endemic species (17.4% of the fauna) in New River, while there are no endemic species in Kanawha River below the falls. Among drainages in the eastern and central United States, only the Mobile River drainage has a higher proportion of endemic species, and no drainage east of the Rocky Mountains has a higher number of endemic species.

The uniqueness of the New River fauna is attributable to the relative isolation of the New River system from adjacent river systems. A major factor isolating New River from other drainages is the 23-25 feet (7.0-7.6 meters) high Kanawha Falls (Sheldon 1988). These falls are located about two miles (three kilometers) below the confluence of the New and Gauley Rivers. While the name of the river does not change from New to Kanawha until the confluence, for ecological purposes Kanawha Falls serve as the boundary between the New and Kanawha Rivers (Jenkins and Burkhead 1994). Kanawha Falls have been a significant, although not complete, barrier to upstream migration of fishes since the Pleistocene.

The low number of fish species in the New River system is not due to loss of New River species, but rather lack of accrual of species from these other river systems (Jenkins and Burkhead 1994). Fish species have entered the New River system by overcoming Kanawha Falls, and by stream capture from adjacent watersheds.

Ascent or bypass of Kanawha Falls (and to a lesser extent New River Gorge and Sandstone Falls) is considered the primary mode of entry to New River (Jenkins and Burkhead 1994). Apparently this was achieved most easily during Pleistocene glaciation. Some of the northern ice sheets reached to the vicinity of the confluence of New and Gauley Rivers. These ice sheets formed a large ice dam on Teays River, creating Teays Lake. Teays Lake inundated Kanawha Falls, and fish species were able to establish viable populations above this barrier. Because of the cool climate prevalent during Pleistocene glaciation, most native New River fishes are adapted to, or tolerant of, cool water.

Hocutt *et al.* (1978, 1979) speculated that during the Pleistocene, some fish species might have reached the New River by first ascending Gauley River, which at that time was more accessible than New River Gorge. Once in the Gauley River system, some of these fish species then entered Greenbrier River system by stream capture. Having reached the Greenbrier system, these fish species then dispersed down Greenbrier River, and up into the upper New River drainage. Also, some of these fish species then entered the James

River and other Atlantic Slope drainages by stream capture. Since these publications, and another based partly on this research (Hocutt *et al.* 1986), these hypotheses have come into question through further research and collecting (Jenkins and Burkhead 1994, Cincotta *et al.* 1999), and re-examination of older data (e.g. Addair 1944).

Table 5. Fish species of the New River with taxonomic classification, common name, and distribution status. Modified from Jenkins and Burkhead (1994).

Family	Genus and species	Common name	Distribution
Petromyzontidae (lampreys)	*Lampetra aegyptera*	least brook lamprey	NI
Amiidae (bowfin)	*Amia calva*	bowfin	I
Anguillidae (freshwater eels)	*Anguilla rostrata*	American eel	Ma
Clupeidae	*Alosa pseudoharengus*	alewife	I
(herrings)	*Dorosoma petenense*	threadfin shad	I
Cyprinidae	*Campostoma anomalum*	central stoneroller	N
(minnows)	*Clinostomus funduloides*	rosyside dace	N
	Cyprinella galactura	whitetail shiner	IP
	Cyprinella spiloptera	spotfin shiner	N
	Cyprinus carpio	common carp	I
	Erimystax dissimilis	streamline chub	Ep
	Exoglossum laurae	tonguetied minnow	N
	Exoglossum maxillingua	cutlips minnow	IP
	Luxilus albeolus	white shiner	NI
	Luxilus cerasinus	crescent shiner	IP
	Luxilus chrysocephalus	striped shiner	NI
	Luxilus coccogenis	warpaint shiner	IP
	Lythrurus ardens	rosefin shiner	NI
	Nocomis leptocephalus	bluehead chub	N
	Nocomis platyrhynchus	bigmouth chub	E
	Notemigonus crysoleucas	golden shiner	I
	Notropis buccatus	silverjaw minnow	N
	Notropis chiliticus	redlip shiner	IP
	Notropis hudsonius	spottail shiner	IP
	Notropis leuciodus	Tennessee shiner	IP
	Notropis photogenis	silver shiner	N
	Notropis procne	swallowtail shiner	IP
	Notropis rubellus	rosyface shiner	N
	Notropis rubricroceus	saffron shiner	IP
	Notropis scabriceps	New River shiner	E
	Notropis stramineus	sand shiner	N
	Notropis telescopus	telescope shiner	I
	Notropis volucellus	mimic shiner	N
	Phenacobius teretulus	Kanawha minnow	E
	Phoxinus oreas	mountain redbelly dace	N

	Pimephales notatus	bluntnose minnow	NI
	Pimephales promelas	fathead minnow	I
	Rhinichthys atratulus	blacknose dace	N
	Rhinichthys cataractae	longnose dace	N
	Scardinius erythrophthalmus	rudd	I
	Semotilus atromaculatus	creek chub	N
Catostomidae (suckers)	*Catostomus commersoni*	white sucker	N
	Hypentelium nigricans	northern hog sucker	N
	Moxostoma erythrurum	golden redhorse	IP
	Thoburnia rothoeca	torrent sucker	Ep
Ictaluridae (catfish)	*Ameiurus melas*	black bullhead	IP
	Ameiurus natalis	yellow bullhead	IP
	Ameiurus nebulosus	brown bullhead	IP
	Ictalurus punctatus	channel catfish	N
	Noturus flavus	stonecat	NI
	Noturus insignis	margined madtom	N
	Pylodictis olivaris	flathead catfish	N
Esocidae (pikes)	*Esox masquinongy*	muskellunge	I
Salmonidae (salmon, trout, etc.)	*Oncorhynchus mykiss*	rainbow trout	I
	Salmo trutta	brown trout	I
	Salvelinus fontinalis	brook trout	N
Atherinidae (silversides)	*Labidesthes sicculus*	brook silverside	I
Cottidae (sculpins)	*Cottus bairdi*	mottled sculpin	N
	Cottus carolinae	banded sculpin	N
	Cottus sp.	Bluestone sculpin	E
Percicthyidae (temperate basses)	*Morone chrysops*	white bass	I
	Morone saxatilis	striped bass	I
Centrarchidae (sunfishes)	*Ambloplites rupestris*	rock bass	I
	Lepomis auritus	redbreast sunfish	I
	Lepomis cyanellus	green sunfish	N
	Lepomis gibbosus	pumpkinseed	I
	Lepomis gulosus	warmouth	I
	Lepomis humilis	orangespotted sunfish	I
	Lepomis macrochirus	bluegill	I
	Lepomis megalotis	longear sunfish	I
	Micropterus dolomieu	smallmouth bass	I
	Micropterus punctulatus	spotted bass	I
	Micropterus salmoides	largemouth bass	I
	Pomoxis annularis	white crappie	I
	Pomoxis nigromaculatus	black crappie	I
Percidae	*Etheostoma blennioides*	greenside darter	N

(perches)	*Etheostoma caeruleum*	rainbow darter	NI
	Etheostoma flabellare	fantail darter	N
	Etheostoma kanawhaw	Kanawha darter	E
	Etheostoma nigrum	johnny darter	N
	Etheostoma osburni	candy darter	E
	Etheostoma simoterum	snubnose darter	NI
	Etheostoma variatum	variegate darter	I
	Perca flavescens	yellow perch	I
	Percina caprodes	logperch	N
	Percina gymnocephala	Appalachia darter	E
	Percina oxyrhynchus	sharpnose darter	N
	Percina roanoka	Roanoke darter	IP
	Stizostedion vitreum	walleye	I

Key to **Distribution**: N = native; NP = probably native but possibly introduced; I = introduced; IP = probably introduced but possibly native; M = marine (catadromous) but occurring within the basin; E = endemic; Ep = native but extirpated.

Stream capture occurs where accelerated erosion in one drainage breaches the divide with another drainage. When this happens, channels with higher elevation tend to alter their course, flowing into channels with lower elevation. Species present in a captured drainage then have the opportunity to establish viable populations in their new drainage. Stream capture has been relatively infrequent, and the narrow shape of the New River watershed indicates that it is more likely to have lost streams than to have gained them in this manner (Jenkins and Burkhead 1994).

Distribution of members of the genera *Phoxinus*, *Phenacobius*, *Cottus*, and *Percina*, suggest dispersal from the upper Tennessee and Cumberland River systems into the New River system (Jenkins and Burkhead 1994). This probably occurred due to stream capture along the southwestern divide of the New River system.

Fish species that most likely entered the New River system from Atlantic Slope streams include mountain redbelly dace, bluehead chub, white shiner, and margined madtom (Jenkins and Burkhead 1994). These fish are present in the New River system, but not in the rest of the surrounding Upper Ohio River drainages.

The New River system is not likely to have captured streams (and fish species) from other surrounding Ohio River tributary drainages (Jenkins and Burkhead 1994). At least 12 upland taxa present in these middle and upper Ohio River drainages are not found in the New River drainage.

As a result of the relatively species-depauperate native fish fauna of the New River system, it has been extremely susceptible to invasion by new species, and is not presently in a state of equilibrium (Jenkins and Burkhead 1994). The New River system has the largest number (43) and proportion (48%) of introduced fish species among major eastern and central North American drainages (Jenkins and Burkhead 1994). Introduction of new fish species to the New River system continues. The most recent addition to the New River fauna is the rudd, a minnow native to Europe (Easton *et al.* 1991). Collections made during the USGS NAWQA program noted range extensions in the New River system for several introduced fish species (Cincotta *et al.* 1999).

One factor that appears particularly important in the introduction and spread of non-native species is the dumping of bait-buckets by anglers (Dan Cincotta, West Virginia Division of Natural Resources, personal communication 1998). Several of the non-native species that are expanding their ranges in the New River system (least brook lamprey, telescope shiner, whitetail shiner, spottail shiner, margined madtom, and variegate darter) are probably benefiting from bait-bucket dumping (Cincotta *et al.* 1999). These introductions and range expansions are probably having a negative impact on native species.

Non-native species are thought to decrease biotic integrity (Miller *et al.* 1988). In the New River system, several endemic species are believed by some biologists to be at risk of competitive exclusion from non-native species. Five of the endemic species (bigmouth chub, New River shiner, tonguetied minnow, Appalachia darter, and candy darter) have been collected from West Virginia, including streams that cross parklands. These fish are considered "Species of Concern" by West Virginia Division of Natural Resources' Natural Heritage Program (West Virginia Division of Natural Resources 1990). The New River drainage has been likened to an unplanned experiment in interactions among introduced fish species (Jenkins and Burkhead 1994). Information collected in the near future may be of great value in interpreting the results of this experiment (Cincotta *et al.* 1999).

Not all of the fish species found within the New River watershed are known to occur within the three parks. Stauffer *et al.* (1980) collected 36 species from New River within New River Gorge. An additional 22 species were collected from the rest of the New River system within the Appalachian Plateaus physiographic province, and a list of 17 more species not collected but believed to occur in that region was provided.

Stauffer *et al.* (1980) collected 30 species from Bluestone River and its tributaries. Not all of these collections were made within Bluestone National Scenic River.

Hocutt *et al.* (1979) collected 50 species, and listed 58 known species, from the Gauley River drainage. Four sites within or adjacent to Gauley River National Recreation Area yielded 27 species. Nineteen species were collected from Meadow River (3 sites) downstream from Anglins Creek. Anglins Creek enters Meadow River a little over three miles (5 km) upstream from the Gauley River National Recreation Area boundary.

Within their geographic ranges, some fish species have a broad distribution, while other species have distributions that are controlled by stream type and available habitat (Jenkins and Burkhead 1994). Widespread in most stream types of the New River system are longnose dace, central stoneroller, white shiner, white sucker, and northern hog sucker. Widespread in smaller streams are brook trout (restricted to cold water), rosyside dace, blacknose dace, creek chub, mottled sculpin, and fantail darter. Widespread in larger streams, chiefly New River, are tonguetied minnow, bigmouth chub, spotfin shiner, silver shiner, rosyface shiner, mimic shiner, bluntnose minnow, channel catfish, flathead catfish, greenside darter, sharpnose darter, logperch, and Appalachia darter.

Microhabitat use by New River fishes has been studied within New River Gorge National River (Lobb and Orth 1987, 1988, 1991). Five habitat-use guilds were identified for New River fishes. The edge-pool guild included bluntnose minnow, logperch, young-of-year

(YOY) and juvenile northern hog sucker, smaller white and striped shiners, white crappie, and all sizes of spotted bass and sunfish, and mimic, spottail, and spotfin shiner. The middle-pool guild included common carp, adult flathead catfish, channel catfish, and muskellunge. The riffle guild included adult bigmouth chub, rainbow and sharpnose darters, YOY flathead catfish, telescope shiner, rosyface shiner, and large white and striped shiners. The edge-channel guild included YOY smallmouth bass, greenside and Roanoke darters, central stonerollers, and YOY bigmouth chub. The generalist guild included juvenile and adult smallmouth bass, and all sizes of rock bass.

Some habitat uses varied with time of day. Adult flathead catfish and northern hog suckers were found in riffles at night but not during the day. Central stonerollers and smallmouth bass were more common in riffles during the day, while rock bass were more abundant at night.

Lobb and Orth (1988) examined habitat requirements of bigmouth chub in New River. These fish used shallow (0.15-0.75 m), moderate velocity (0.05-0.69 m/s) areas with abundant small to large gravel (3-64 mm diameter) for constructing spawning mounds. Spawning began in mid-April, apparently peaked in mid-May, and ended in mid-June. Other minnows, including central stonerollers and striped shiners, spawned in bigmouth chub nests. During late summer, bigmouth chub were observed only in riffles and adjacent runs. They stayed near the bottom, where current velocities were lower.

Graham and Orth (1986) found that New River smallmouth bass spawned between late April and mid-July. During this time, mean daily water temperatures ranged from 12.5 to 23.5 C (54.5 to 74.3 F). Spawning activities were interrupted by flooding in June, and resumed as water levels receded. Frequency distributions of spawning dates were nearly identical among study sites, as was the timing of hydrologic events. Mean daily water temperature explained most of the variation among groups of daily stream conditions related to spawning activities.

Austen (1984) and Easton *et al.* (1995) examined feeding by New River smallmouth bass. Fish between 152 mm and 228 mm (6 – 9 in.) fed mainly on insects. Fish between 229 mm and 304 mm (9 – 12 in.) consumed more crayfish and fish in the West Virginia section of New River, while fish in the Virginia section still consumed a sizable proportion on insects. Diets of fish larger than 304mm consisted almost entirely of fish and crayfish.

Austen (1984) and Austen and Orth (1988) compared characteristics of smallmouth bass populations in Virginia and West Virginia sections of New River. West Virginia fish grew faster at all ages except for age 2 than did Virginia fish. This resulted in West Virginia fish being larger at age five, averaging 331 mm (13 in.), versus 280 mm (11 in.) for Virginia fish. Relative weight (weight at a given size) was greater for West Virginia fish in one year of the study, but results were inconsistent in the second year.

As in many other aquatic ecosystems, temperature is an important factor governing the distribution of fishes and other aquatic organisms in New River (Stauffer *et al.* 1976). Cherry *et al.* (1977) examined temperature preference and tolerance in several minnow species from the New River system. Final temperature preferences were 21 C for telescope shiner, 26.1 C for rosy shiner, 26.2 C for fathead minnow, 26.6 C for central stoneroller, 28.4 C for bluntnose minnow, and 31.0 C for spotfin shiner. Shingleton *et al.* (1981) found the final temperature preference of New River shiner was 19.3 C.

The Index of Biotic Integrity (IBI) proposed by Karr (1981) has been widely used to assess the status of fish communities, and to evaluate the impacts of human influences on those communities (Hocutt 1981). The original model must often be modified to accommodate local differences. Leonard and Orth (1984) developed and tested an IBI for streams tributary to New River within New River Gorge National River.

Determining the effects of river regulation on fish populations in New and Gauley Rivers is problematic, since no quantitative pre-regulation data exist. Many New and Gauley River fish species need gravel bars to spawn. Gravel bars are present, and new gravel bars are being formed, in the deposition zone of inflows from unregulated tributaries. The Bluestone and Meadow rivers are unregulated, as are the minor tributaries. The presence of a major unregulated tributary, Greenbrier River, just upstream of New River Gorge National River, provides periodic high flows to the New River sufficiently powerful to move gravel and cobble about the stream bottom. Likewise, the Meadow River provides periodic high flows to Gauley River reach below their confluence. Only the reach of the Gauley River upstream from Meadow River to Summersville Dam is almost completely regulated (with the exception of some minor tributary inflow). However, even its higher flows from dam releases can shift the river substrate, as is evidenced by changes common in the stage-discharge rating of the USGS gauge downstream from Summersville Dam (John Atkins, U.S. Geological Survey, personal communication 1999). It is unlikely that any native fish species was extirpated from the New River system because of impoundment (Jenkins and Burkhead 1994).

The New River within New River Gorge National River is one of the most important warm-water fisheries in West Virginia. New River contains excellent warm-water fish habitat, with a pool-riffle geomorphic structure, abundant cover, and generally good chemical quality. New River game fish include muskellunge, channel and flathead catfish, white and black crappie, several species of sunfish, smallmouth, spotted, and largemouth bass, and walleye (National Park Service 1994a). The earliest surveys of the New River system reported few game fish (Cope 1868). Most game fish presently found in the New River system were deliberately introduced, and only four game fish species, American eel, channel and flathead catfish, and green sunfish are recognized as native (Jenkins and Burkhead 1994).

Fishes were also surveyed as part of EPA's EMAP program. This data is available on-line (< http://www.epa.gov/emap >), and was summarized in general terms in the Mid-Atlantic Highlands report (Environmental Monitoring and Assessment Program 2000).

Other Vertebrates

Terrestrial vertebrates are abundant and diverse in riparian zones near Bluestone, New, and Gauley Rivers (Pauley 1993). A 1987 biological survey of New River Gorge documented over 100 species of birds, 30 species of small mammals, and 41 species of amphibians and reptiles (Buhlman *et al.* 1987). The actual number of bird and mammal species in these areas is expected to be about twice what this study found (John Perez, New River Gorge National River, personal communication 2001). Beaver (*Castor* *canadensis*) and muskrat (*Ondatra zibethicus*) were found during the survey. Several species of ducks (Anatidae), Canada geese (*Branta canadensis*), great blue and green-backed herons (*Ardea herodias* and *Butorides striatus*), osprey (*Pandion haliaetus*), and kingfishers (*Ceryle alcyon*) are among the birds that spend a substantial amount of time in or near the water. Recently, river otter (*Lutra canadensis*) have been introduced into the New River area (Curtis Taylor, West Virginia Division of Wildlife Resources, personal communication 1997).

Several reptiles are generally found inor near water (Green and Pauley 1987). Water snakes (*Nerodia sipedon*) and queen snakes (*Regina septemvittata*) frequent streams and are found in New River Gorge. Snapping turtles (*Chelydra serpentina*), map turtles (*Graptemys geographica*), painted turtles (*Chrysemys picta*), eastern river cooter (*Pseudemys c. concinna*), and spiny softshell (*Trionyx spiniferus*) are known from New River Gorge or nearby areas. All four of these turtles spend much or most of their time in or near water, but none of them are abundant. Bones of the eastern river cooter were found at an archeological site near Bluestone Lake, confirming that this species is native (Seidel 1981, 1982).

Several amphibians are also common to abundant in the New River Gorge area (Green and Pauley 1987, Pauley 1993). Among the toads and frogs are spring peeper (*Pseudacris cruciferans*), gray tree frog (*Hyla versicolor* or *H. chrysoscelis*), green frog (*Rana clamitans melatona*), bullfrog (*Rana catesbeiana*), and American toad (*Bufo a. americana*).

Several permanently aquatic salamanders are found in New River Gorge or surrounding counties (Green and Pauley 1987). The hellbender (*Cryptobranchus alleganiensis*) is a large (up to 20 inches) salamander that prefers cool, clear, mountain streams. Hellbenders are of special scientific interest in West Virginia (West Virginia Division of Natural Resources 1990). Although they are nocturnal and hide during the day, they respond strongly to electric current and are occasionally seen by electrofishing crews. Adult red-spotted newts (*Notopthalmus viridescens*) are common and abundant in New River and nearby streams. Three stream salamanders of genus *Desmognathus* are found in small streams of New River Gorge: the northern dusky salamander (*D. f. fuscus*), the Appalachian seal salamander (*D. m. monticola*), and the blackbelly salamander (*D. quadramaculatus*). Blackbelly salamanders are commonly used as fish bait, and are sometimes harvested by bait dealers. They are thought to be declining in abundance. Other stream salamanders of the area include the spring salamander (*Gyrinophilus porphyriticus*), northern red salamander (*Pseudotriton r. ruber*), northern two-lined salamander (*Eurycea bislineata*), and longtail salamander (*Eurycea l. longicauda*), all of which are found in springs or small headwater streams.

<u>Invertebrates</u>

<u>Mollusks</u>

Seven species of live mussels (Unionidae), and shells of an eighth, were collected in New River Gorge National River during a 1984-85 study (Jirka and Neves 1987). Mussels were much more common towards the upstream end of the park, decreasing significantly below Glade Creek. No living or dead mussels were found in the lower eight miles of river within the park.

The majority of mussel beds sampled contained aquatic macrophytes, although none were found in beds downstream of Glade Creek (Jirka and Neves 1987). Cover of vegetation ranged from 0 to 28 percent of total bed area. The dominant macrophyte was listed as water star-grass, *Heteranthera dubia*. *Potamogeton* spp. and *Elodea canadensis* were also common. The reference to *Heteranthera dubis* probably refers to *Heteranthera dubia*. This species otherwise has not been reported from the park. Since this species, when not in bloom resembles *Potamogeton zosteriformis* (Hotchkiss 1972), this latter species may be the one that was commonly found in the mussel beds.

Mucket (*Actinonaias carinata*) was by far the most common species found by Jirka and Neves (1987). It composed over 90% of the individuals collected, and occurred in all areas where mussels were found. Purple wartyback (*Cyclonaias tuberculata*) and spike (*Elliptio dilatata*) were next most common, comprising approximately four and two percent, respectively, of the mussel fauna. These species were also present in all mussel beds. Buckhorn, or pistol-grip, (*Tritogonia verrucosa*) were relatively common (~2% of the fauna) above Sandstone Falls, but much less common below this point. Elktoe (*Alasmidonta marginata*), wavy-rayed lamp, (*Lampsilis fasciola*), and pocketbook (*Lam. ovata*) were collected in very small numbers. Shells of wavy-rayed lamp and pocketbook were collected in many mussel beds where no live individuals of these species were found. Shells of green floater (*Lasmigona subviridis*) were also collected during the survey. West Virginia lists all native mussels as species of special concern.

Several other mussels have been collected or reported from the New River Gorge area. Empty valves of giant floater (*Anodonta grandis*) have been found immediately below Bluestone Dam and near the lower end of Brooks Falls (Jirka and Neves 1987). Lilliput (*Toxolasma parvus*) has been collected in the lower New River only near the mouth of the Gauley River (Jirka and Neves 1987). A single specimen of rainbow (*Villosa i. iris*) was reported from Bluestone River (Tolin 1985). Mapleleaf (*Quadrula quadrula*) was reported from Sandstone Falls, but this report is questionable because no other record exists for this species from the entire New River drainage (Jirka and Neves 1987). In 2002 a single live mapleleaf was positively identified from the New River in the Stonecliff area.

An exotic bivalve mollusk, the Asiatic clam (*Corbicula fluminea*), has become well established in New River since at least 1975 (Rogers *et al.* 1979). Population numbers, biomass, and production of this organism probably greatly exceed those of all native mussels. Unlike Unionidae, Corbicula have ciliated, free-swimming larvae (Pennak 1989). Therefore they do not require a specific fish host to complete their life cycle. Another invasive exotic, the zebra mussel (*Dreissena polymorpha*) has not yet been reported in New River (U. S. Geological Survey 1999). Zebra mussels are well established in Kanawha River and could easily be introduced to heavily boated Bluestone Lake at any time. No recent, detailed studies have been made of the mussels of Bluestone or Gauley Rivers.

Like the fish fauna, the unionid mussel fauna of New River is relatively depauperate. In Kanawha River downstream from Kanawha Falls, 34 species, including the federally listed endangered pink mucket (*Lam. orbiculata*), have been described. Some of the same barriers that prevented fish migration also may have prevented mussel migration. Also, unionids require specific fish hosts to complete their life cycle, so the depauperate nature of the fish community of New River may contribute to the depauperate mussel community.

All native North American mussel larvae are obligate temporary parasites of fish (Pennak 1989). This larval form, termed a glochidium, is a small (less than ½ mm), superficial copy of the adult. After being expelled by the parent, the glochidium lies on the bottom until contacted or taken in by a fish. Those that do not find a host within several days die. The glochidium becomes attached to the gills, fins, or body surface of the host. Tissue from the host grows around the glochidium within a day or two, forming a small cyst. There is little evidence that this infestation harms fishes in natural habitats. During the encysted stage, which lasts from 10 to 190 days depending on species and temperature, most of the adult organs develop, although the larva does not grow in size. As the larva completes this stage, it breaks out of the cyst, settles on the bottom, and begins the juvenile phase of its life. This stage lasts from one to eight years, depending on species, until sexual maturity is attained.

Mussels feed by filtering particles out of the water (Pennak 1989). They are the dominant filter feeders in many shallow-water ecosystems (Strayer *et al.* 1999), filtering large amounts of water (Lauritsen 1986, Kryger and Riisgard 1988, Wallace *et al.* 1977). The invasive exotic species, *C. fluminea* and *D. polymorpha*, have very high filtering rates. While such high filtering rates can increase water clarity (Haines 1977), this comes at the expense of other species that rely on these particles for nutrition. Mussels use bacteria for their main source of dietary carbon, while diatoms and green algae provide other important nutritional components, such as vitamins A and D, and phytosterols (Nichols and Garling 2000).

Little information is available on the aquatic gastropod mollusks (snails) in the New River system, including the three parks.

<u>Crayfish</u>

Six species of crayfish are known from New River Gorge (National Park Service 1994a). Five species (*Orconectes s. sanbornii*, *O. virilis*, *O. spinosus*, *Cambarus bartonii carinirostris*, and *C. sciotensis*) are widespread (to differing degrees) in the New River Gorge area (Jezerinac *et al.* 1995). A sixth species (*O. obscurus*) has also been collected from New River (Markham *et al.* 1980). The two *Cambarus* species are also found in the Gauley River basin, and *C. b. carinirostris* is known from Bluestone River. *Cambarus bartonii cavatus* is listed as rare upstream from Kanawha Falls, and is found primarily above 1500 feet of elevation.

The two *Cambarus* species are considered native. *Orconectes virilis* was introduced to Bluestone Lake prior to 1972 (Edmundson 1974). By 1979 *O. virilis* comprised 90% of the crayfish collected at five seine sites between Bluestone Dam and Sandstone Falls (Markham *et al.* 1980). It is likely that *O. s. sanbornii* was introduced to New River at a later date, as none were collected in 1979. By 1983-1985 they were the predominant crayfish in the 1.1km below Bluestone Dam (Roell and Orth 1992). Also, *O. obscurus* comprised 3% of the assemblage in 1979 (Markham *et al.* 1980), but were not collected in 1984 or 1985 (Roell and Orth 1992). Non-native crayfish were likely introduced to New River by anglers as discarded or escaped bait (Miller 1997). Introduction of non-native crayfish into areas inhabited by native species (e.g. Hill and Lodge 1999), along with the restricted ranges of most crayfish, are major factors in about 50% of U.S. and Canadian crayfish being in need of conservation recognition (Taylor *et al.* 1996).

Several other crayfish species have been collected or reported near the parks. The New River crayfish (*C. chasmodactylus*) is a species of special concern (West Virginia Division of Natural Resources 1990). Although Jezerinac *et al.* (1995) considered *C. chasmodactylus* restricted to the Greenbrier River basin, this species has been reported from the Bluestone (Hobbs 1989) and East (James 1966) rivers. There are reports of *C. longulus* in the Valley and Ridge physiographic province of the New River Basin in Virginia (Jezerinac *et al.* 1995). According to Hobbs (1989), this species is found in the mountains and piedmont of Atlantic coast drainage systems. Therefore a specimen in the New River in West Virginia would likely be a recent bait bucket introduction. There are also reports of *C. veteranus*, another species of special concern, from the upper Bluestone River Basin, but not from other streams in the vicinity of the parks (Jezerinac *et al.* 1995). This species had previously only been collected in the Guyandot and Big Sandy River drainage systems, but the limits of its range are very indefinite and poorly known (Hobbs 1989). *Cambarus robustus*, widespread throughout the northeastern United States (Hobbs 1989), is common downstream from Kanawha Falls. Although a disjunct population has been reported from the Greenbrier River Basin, it is not known throughout most of the New River drainage (Jezerinac *et al.* 1995). *Cambarus necterius*, another species of special concern, is endemic to caves of the Greenbrier River system in the New River Basin (Hobbs 1989).

Crayfish are a large part of a significant bait fishery that exists in New River between Bluestone Dam and Sandstone Falls (Nielsen and Orth 1988). Annual harvest by anglers and commercial bait catchers was about 5% of annual production (Roell and Orth 1992). Overall crayfish production in this reach was about 7.0 grams live weight per square meter per year (Roell and Orth 1992). About half the production was by *C. sciotensis*, and the rest by *O. virilis* and O. *s. sanbornii*.

<u>Benthic Macroinvertebrates</u>

The NPS Long Term Ecological Monitoring System (LTEMS) is the primary source for recent benthic macroinvertebrate data for New River in New River Gorge. Prior to 1998 LTEMS sampled five sites: Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station. Fayette Station was dropped after 1997 due to lack of suitable habitat, and safety concerns for sampling staff and the recreational public.

The collections discussed below were made from 1988 to 1990 (Voshell and Orth 1995). Invertebrates were most abundant at Bluestone Dam. At least 12 families were present. Two families, Hydropsychidae (net-spinning caddisflies) and Chironomidae (midges) together accounted for almost 90% of the community. The Sandstone Falls community was more balanced with a greater variety of families than at any other site. Usually, seven families accounted for more than one percent of the community. Hydropsychidae (30%) were most abundant. Midges (10%) were much less abundant than at Bluestone

Dam. Three mayfly families (Oligoneuriidae, Baetidae, and Ephemerellidae) together comprised about 40% of the community. Also present in substantial numbers were riffle beetles (Elmidae) and gill breathing snails (Pleuroceridae). Fourteen invertebrate families were collected at Thurmond. Baetidae (50%), midges (15%), and Pleuroceridae (10%) were most abundant. Fayette Station had the lowest taxa richness (8 families) of the five sites. Heptageniid mayflies (25%), Elmidae (25%), and midges (20%) were most abundant.

Voshell and Orth (1995) also calculated production at the Bluestone Dam and Sandstone Falls sites for taxa that occurred in sufficient numbers to allow such calculation. Abundant taxa at Bluestone Dam were *Baetis intercalis, Heterocloen curiosum, Cheumatopsyche campyla, Simulium jenningsi, S. vittatum*, and Chironomidae. Abundant taxa at Sandstone Falls were *B. intercalis, Serratella deficiens, Tricorythodes* sp.*, C. campyla, Oecitis sp., S. jenningsi,* and Chironomidae.

The USGS NAWQA program collected invertebrates from seven sites within or near parklands in 1997 to 1998. These sites were Bluestone River at Spanishburg (above BLUE), Camp Creek at Camp Creek (above BLUE), Little Bluestone River at Jumping Branch (above BLUE), New River at Thurmond (in NERI), Mill Creek near Hopewell (above NERI), Millers Creek at Nallen (above GARI), and Peters Creek near Lockwood (above GARI). Taxonomic information and abundance are presented in Ward *et al.* (1999).

Other benthic macroinvertebrate data collected in the New River Gorge area usually are presented in the form of qualitative indices (West Virginia Department of Environmental Protection 1998). The West Virginia Division of Environmental Protections collects benthic invertebrate data from small streams around the state, rotating watersheds on a 5-year cycle. The U.S. EPA's Rapid Bioassessment Protocol (RBP) II is used, with laboratory identification (Janice Smithson, West Virginia Division of Environmental Protection, personal communication 1999). Taxonomy data are archived and available for analysis beyond the qualitative assessments of stream impairment. Parklands are split among three watersheds, Upper New (including Bluestone River), Lower New, and Gauley. The Gauley watershed was sampled in 1997, and the Lower New watershed was sampled in 1999.

The EPA's EMAP collected benthic invertebrates using RBP II protocols as part of the Mid-Atlantic Highlands Assessment. Some of this data was collected by personnel from the West Virginia Division of Environmental Protection. The data is available on-line (< http://www.epa.gov/emap >), and was summarized in general terms in the Mid-Atlantic Highlands report (Environmental Monitoring and Assessment Program 2000).

Floodplains, Riparian Areas, and Wetlands

Floodplains, riparian areas, and wetlands occur at the interface between land and water. Collectively these areas represent only a small proportion of the landscape in the three parks. However, their hydrologic and ecological importance is very significant (Buhlmann *et al.* 1987, Naiman *et al.* 1993). Individually and collectively, these areas provide many critical functions including water supply, maintenance of water quality, flood attenuation, essential habitats for flora and fauna, and maintenance of biodiversity.

Floodplains

Flood profiles, inundation maps, and floodway determinations are available for some of the New, Gauley, and Bluestone Rivers within park boundaries. The Federal Emergency Management Agency (FEMA) is the primary source for obtaining flood information, and USGS has also published flood data for park areas.

New River Gorge National River falls within the Summers and Fayette county FEMA studies (Federal Emergency Management Agency 1980, 1988). Flood profiles for the 10-, 50-, 100-, and 500-year recurrence intervals were computed, inundation maps for the 100- and 500-year events were prepared, and the floodway was determined for New River from the upstream park boundary to the Fayette-Summers County line. New River in Fayette County was not studied by FEMA. Portions of streams within New River Gorge National River boundaries tributary to New River studied by FEMA include Brooks Branch, Kates Branch, Laurel Creek, Lick Creek, Meadow Creek, Mill Creek, Wolf Creek, and Dunloup Creek (Federal Emergency Management Agency 1980, 1988). The USGS determined 2-, 25-, and 100-year flood profiles for New River within New River Gorge National River boundaries, but no inundation map was prepared, nor floodway determined (Wiley and Cunningham 1994). Portions of streams tributary to New River within New River Gorge National River studied by USGS include Wolf Creek, Craig Branch, Manns Creek, Dunloup Creek, and Mill Creek (Wiley 1994).

Gauley River National Recreation Area falls within the Fayette and Nicholas County FEMA studies (Federal Emergency Management Agency 1988, 1991). Neither Gauley River, nor any Gauley tributaries, was studied by FEMA within park boundaries. The USGS has not published any flood data within park boundaries.

Bluestone National Scenic River falls within the Summers and Mercer county FEMA studies (Federal Emergency Management Agency 1980, 1995). Bluestone River was studied from the upstream park boundary to the Mercer-Summers county line. Flood profiles for the 10-, 50-, 100-, and 500-year recurrence intervals were computed, inundation maps for the 100- and 500-year events were prepared, and the floodway was determined. The Bluestone River within the park boundary was not studied by FEMA in Summers County. No tributary streams to the Bluestone River within park boundaries were studied by FEMA. The USGS has not published any flood data within park boundaries.

Riparian Areas

Natural riparian areas are some of the most diverse, dynamic, and complex biophysical habitats in the terrestrial environment (Naiman *et al.* 1993). The riparian area encompasses the stream channel between low and high water marks, and that portion of the terrestrial landscape above the high water mark where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997). Thus, riparian areas are ecotones between the aquatic habitat of a river and the surrounding terrestrial habitats. The riparian zone may be small in headwater streams. In mid-sized streams the riparian zone is larger, being represented by a distinct band of vegetation whose width is determined by long-term (>50 years) channel dynamics and the annual discharge regime. Riparian zones of most large streams are characterized by well-developed but physically complex floodplains with long periods of seasonal flooding, lateral channel migration, oxbow lakes in old river channels, a diverse vegetative community, and most soils (Malanson 1993). These attributes suggest that riparian zones are key systems for regulating aquatic-terrestrial linkages and that they may be early indicators of environmental change (Decamps 1993).

Buhlmann and Vaughan (1985) and Buhlmann *et al.* (1987) characterized riparian areas within New River Gorge National River, and developed an extensive list of plants associated with riparian habitats. This summary draws mainly from these descriptions.

Riparian sites in the southern section of New River Gorge, Hinton to Meadow Creek, consist primarily of small floodplain forests with sycamore (*Platanus occidentalis*), river birch (*Betula nigra*), black willow (*Salix nigra*) and silver maple (*Acer saccharinum*) constituting most of the canopy (Buhlmann *et al.* 1987). Much of the floodplain forest has been cleared or altered for farmland, industry, and town and home sites.

A few unusual riparian habitat types occur in the southern section of the Gorge. These include a site dominated by Virginia pine (*Pinus virginiana*) and quaking aspen (*Populus tremuloides*), and a talus slope near the I-64 bridge over New River that is dominated by eastern hemlock (*Tsuga canadensis*) and upland hardwoods. An unusual floral community, the Appalachian Rivers Flatrock Community, occurs on flat sandstone ledges at three locations within the park. This community includes several rare sedges (*Carex* spp.)

Downstream of Meadow Creek, the river channel narrows, stream gradient increases, and wide floodplain habitats are sparser. Rock rip-rap habitats predominate, with only a narrow band of riparian hardwoods separating the river from the upland forest. Wider floodplains are found at the confluence of major tributaries, such as Glade Creek in Raleigh County. Downstream from Thurmond, large talus blocks of sandstone from the cliffs above become the dominant riparian shoreline.

Tributary riparian areas were characterized primarily by hemlock, yellow birch (*Betula lutea*), red maple (*Acer rubrum*), and buckeye (*Aesculus glabra*). The common understory vegetation in these areas included rhododendron and ferns.

Buhlmann *et al.* (1987) classified riparian areas into the following 10 habitat types (Table 6): mature sycamore; willow; sycamore willow birch; stunted sycamore/willow; hemlock/rip-rap; riparian Virginian pine; rock riprap; boulder; tributary; and developed.

Other than a cursory understanding of the presence of plant species, the riparian zones in the three park units are unstudied. More importantly, it is not known how healthy these areas are, and if they are functioning properly to afford the park's water resources maximum ecological protection, given the history of flow regulation.

Similarly, the condition of riparian areas throughout West Virginia is poorly known. In 1997, the West Virginia Division of Environmental Protection initiated an assessment of riparian habitat integrity on selected watersheds, none of which includes the three parks.

Plans called for data collection on all state watersheds to be completed by 2001. Riparian areas would be sampled along the 100-meter reaches that are also sampled by the agency's existing water quality monitoring program. The assessment uses a modification of EPA's Rapid Bioassessment Protocols habitat evaluation procedures (U.S. Environmental Protection Agency 1989). This modification assesses vegetation present in each of three categories – canopy, understory, and ground cover; and, assesses stream surface shading, bank stability, bank vegetation protection, disruptive pressure, and riparian vegetative zone width.

Wetlands

The West Virginia Division of Natural Resource's West Virginia Wetlands Inventory began in 1975. The project inventoried all known channel wetlands, and non-channel wetlands exceeding 5 acres in area.

The U. S. Fish and Wildlife Service's National Wetlands Inventory (NWI) began in 1974. The primary purpose of the NWI is to produce detailed maps showing the location, type, and distribution of wetlands. NWI maps wetlands as small as 1/8 acre. For this reason and others, the West Virginia Wetlands Conservation Plan of 1987 adopted NWI as the standard for wetlands in the State.

National Wetland Inventory data indicate approximately 14% of West Virginia's total wetlands are concentrated in two major wetland complexes. One of these, Meadow River upstream of the Gauley River National Recreation Area boundary, contains 5% of the State's wetlands.

A total of 299 wetlands are delineated on NWI maps for the three parks. The most dominant wetland types (Cowardin *et al.* 1988) by numbers include unclassified (potential wetlands) at 16.7%, temporarily flooded riverine wetlands on unconsolidated shore (14.7%) or rocky shore (14.4%), permanently flooded riverine wetlands with unconsolidated bottoms (8.4%), and temporarily flooded, broad-leaved deciduous, palustrine wetlands (14.7%). As expected, riverine wetlands are the most dominant type of wetland (37.5%), primarily because of a lack of floodplain development in river and tributary gorges. Riverine wetlands are located in the river channel where the water is usually flowing, and bounded on the upland side or channel bank. Temporarily flooded refers to surface water that is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Seasonally, flooded refers to surface water that is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. Unconsolidated shore includes all wetlands that have: 1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock; and, 2) less than 30% areal cover of vegetation. Unconsolidated bottom includes all wetland habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. Rocky shore includes wetlands characterized by bedrock, stones, or boulders that singly or in combination have an areal cover of 75% or more, and an areal coverage of vegetation of

Table 6. Riparian Habitat Classifications along the New River Gorge National River (modified from Buhlmann *et al.* 1987).

Habitat Classification	Major Overstory	Understory	Ground Cover	Slope	General Distribution
Mature Sycamore (SYC)	sycamore slippery elm honey locust	poison ivy	sand grasses self-heal ragweed ox-eye daisy	0-10%	Hinton-Thurmond
Description: sites of deposition, usually at bends in the river or islands. Occurring on sandy soils, usually little understory, often as a result of heavy camping impacts.					
Willow (W)	black willow		sand mud grasses	0-20%	near Prince
Description: similar to above, soils contain more sand. Pure willow stands are not common in the Gorge.					
Sycamore Willow Birch (SWB)	honey locust silver maple	buckeye poison ivy	sand, mud cobble stinging nettle ragweed	0-10%	Hinton-Cunard
Description: similar to willow and sycamore usually more cobble in the soil.					
Stunted Sycamore/ Willow (SSW)			grasses cobble water willow	0%	Glade-Cunard
Description: cobble and boulder understory, trees stunted growth due to flooding damage, stripped of soil, often submerged, especially in spring.					
Hemlock/Rip-rap (HRR)	hemlock yellow birch		rock	45%	I-64 area
Description: rock riprap area dominated by hemlocks and upland hardwoods, little understory.					
Riparian Virginia Pine (RVP)	virginia pine river birch sycamore	hazel alder	grasses	0-10%	Hinton – I64 bridge area
Description: small clumps of pines within young SWB habitat, an unusual riparian community type.					
Rock Rip-Rap (RRR)	red oak sycamore river birch		rock	>30%	Meadow Creek – Fayette Station
Description: little or no vegetation, slope usually greater than 30%, common in northern 2/3 of the Gorge.					
Boulder (B)	sycamore yellow birch sweet gum		large rock	>30%	Cunard – Rt 19
Description: large rock boulders, associated with the northern 1/5 of the Gorge where the river is narrow and the slopes are steep.					
Developed (DEV)	varied	varied	grasses bare soil	0-20%	Hinton area
Description: areas along the river heavily altered by man. Driveways, homes, trailers, and docks are common.					
Tributary Stream Gorges (TSG)	hemlock yellow birch buckeye	rhododendron bracken fern	sandstone exposed rock		entire Gorge area
Description: usually hemlock and mixed hardwood stands associated with the secondary streams entering the New River Gorge, sunlight penetration restricted. Similar to upland hardwoods.					

less than 30%. Palustrine wetlands are all nontidal wetlands dominated by trees, shrubs, and persistent emergents. The palustrine system was developed to group vegetated wetlands traditionally called by such names as marsh, swamp, bog, and fen (Cowardin *et al*. 1979). Broad-leaved deciduous refers to dominant trees such as red maple, American elm (*Ulmus americana*), and ashes (*Fraxius* spp.), among others.

A wetland delineation study (unknown date; in park files) was conducted for the New River between Hinton and the I-64 bridge. Wetland delineations were based on available National Park Service color aerial photographs. These delineations were ground-truthed, something not done for the NWI maps. For this stretch of New River Gorge, NWI maps show 49 wetlands representing 11 wetland types. The National Park Service study delineated 76 wetlands representing 21 wetland types. The dominant type for NWI was unclassified (potential wetlands) (53%) followed by palustrine (43.4%). For the National Park Service study dominant wetland types were the broad leaved deciduous palustrine wetlands (43.4%; either temporarily, seasonally or intermittently flooded), followed by riverine wetlands (32.9%; either intermittently flooded aquatic beds, rocky bottoms, or unconsolidated bottoms). Two things are striking: 1) the difference in total wetlands identified (76 in the NPS study vs. 49 for the NWI maps); and the difference in the riverine wetlands (32.9% by NPS vs. 3.6% by NWI). The differences are probably attributable to the ground-truthing of wetland delineations. The 35.5% difference in total wetlands is significant for this reach. If this difference were extrapolated to all three parks, then the total number of wetlands would be 405.

National Wetland Inventory maps are useful for a general understanding of the potential areal extent and types of wetlands that are present. However, these maps are often based on outdated aerial photography, not ground-truthed, and the scale (1:24,000) is not adequate to detect subtle changes that may be occurring with respect to habitat boundaries or species composition changes, or delineate small wetland types, such as seeps or springs.

Endangered and Rare Species

No aquatic, federally listed endangered or threatened species are known from the Bluestone, New, or Gauley rivers. West Virginia does not have a state law protecting endangered species. The West Virginia Natural Heritage Program lists some rare species as being of special scientific concern (West Virginia Division of Natural Resources 1990). One of these species, the candy darter, is endemic to the New River system, and has been collected from tributaries of Bluestone, New, and Gauley Rivers. An extensive survey of streams where it had been historically collected showed its populations to remain fairly well established (D.A. Cincotta, West Virginia Academy of Science annual meeting, personal communiation 1998). However, it was not collected at all of the historical sites, including Peters Creek, a tributary of the Gauley River National Recreation Area. The candy darter is thought to be at risk of competitive exclusion from the closely related, non-native variegate darter, which is expanding its range in the New River drainage system.

The federally endangered pink mucket pearly mussel is known from the Kanawha River downstream of Kanawha Falls (about 2 miles downstream from the confluence of New and Gauley Rivers). The pink mucket pearly mussel has never been collected from the New River, and may not be native upstream of Kanawha Falls.

A community of locally rare sedges and other plants, known as the Appalachian River Flatrock Community (Bartgis 1985, Trianosky 1994, Walton *et al.* 1997, Suiter and Evans 1999, Vanderhorst 2000) is known at five sites in New River Gorge. Three of these sites are within New River Gorge National River (Rouse and McDonald 1986). This community is dependent on the scouring evinced by occasional flooding for its long-term integrity. Operation of dams that reduce this flooding may imperil this community.

PARK DEVELOPMENT AND OPERATIONS

Treatment of wastewater generated by NPS facilities within New River Gorge National River is handled by several different methods. Wastewater from Canyon Rim Visitor Center is treated by a sewage treatment facility operated by the park. This facility holds treated wastewater in sewage lagoons for three to four weeks before releasing it into the normally dry streambed of an unnamed tributary to New River. A small package plant discharges treated wastewater from the Thurmond Depot Visitor Center into New River. Wastewater from NPS headquarters in Glen Jean enters the White Oak Public Service District collection system, and is treated at their sewage treatment plant just upstream of the park boundary on Dunloup Creek. Construction has begun on a new visitor center near the I-64 Sandstone exit. Wastewater from this facility will be treated at a new sewage treatment plant under construction in the Sandstone area. Septic systems are used at Camp Brookside near Hinton, Dunglen across New River from Thurmond, and Grandview. The NPS has constructed of a package plant at Grandview. Park restroom facilities within New River Gorge National River use aerated vault toilets for waste storage where water and sewer hookups are not available. Four such facilities are in use, and three more are planned. A company that is certified by the State of West Virginia pumps these toilets as needed, and provides the NPS with sludge manifest reports to document proper waste disposal techniques (Chris Thompson, formerly New River Gorge National River, personal communication 1998). Wastewater from a restroom in Gauley River National Recreation Area below Summersville Dam is pumped up to a U.S. Army Corps of Engineers treatment facility at the dam. There is presently no development in Bluestone National Scenic River that requires wastewater treatment.

The NPs maintains a vehicle repair shop at Dunglen that services vehicles and equipment for the three parks. Every three months a private cleaning company provides a cleaning service for greasy parts. The same company transports all waste materials such as used motor oil, transmission and hydraulic fluids, and paint thinners from the parks as needed.

Snow removal is accomplished by NPS-owned plows and by chemical treatment. The NPS applies a mixture of urea and sand to sidewalks and roads at Grandview, and to sidewalks and parking lots at park headquarters in Glen Jean and at Grandview (Chris Thompson, formerly New River Gorge National River, personal communication 1998).

STAFFING AND ONGOING PROGRAMS

Staffing

Full-time staff responsible for water-resource management of the three parks includes a supervisory resource management specialist, a fishery biologist, and three biological science technicians. Staff duties are outlined below. During summer, additional paid staff, as well as volunteers, may be temporarily employed. All of these positions fall under the direction of the Deputy Superintendent for Resource Management and Planning. A Criminal Investigator, often assisted by law enforcement rangers, investigates and gathers evidence for prosecution of environmental crimes such as illegal discharges and dumping. These employees work in the Division of Visitor Protection under the Deputy Superintendent for Operations.

Staff Duties

Supervisory Resource Management Specialist:

This person has overall supervision and oversight for the Branch of Resource Management. He/she assigns priorities and workloads and coordinates resource management efforts within the parks.

Fishery Biologist:

This person serves as program manager/team leader for water resources in the three parks. He/she sets priorities and coordinates the work effort of the water resources staff. He/she evaluates ongoing water resource efforts and makes necessary changes, and identifies data gaps and takes steps to fill these gaps. He/she evaluates the potential impact of real and proposed activities, both within and outside the parks, to park water and aquatic resources. This individual also assists in field and laboratory efforts within the water resources program.

Biological Science Technician:

While there is overlap, support, and coordination between these three positions, their basic duties can be separated. One position functions as manager of the National Park Service water quality laboratory. He/she is responsible for all aspects of the parks' water quality lab. This individual oversees operation and maintenance of the lab, ensures that necessary equipment and supplies are adequately stocked and in proper working order, maintains water-quality data, and ensures that water-quality samples and analyses meet appropriate standards for collection and processing. A second position functions as manager of the National Park Service aquatic biology laboratory. This individual is responsible for all aspects of the aquatic biology lab, keeps track of samples collected and progress in their sorting, enumeration, and identification, ensures that samples and reference specimens are properly maintained, and oversees seasonal help and volunteers who are working in the water resources program. This person also assists with field data efforts of the water resources program. The recently filled third position has been assigned a variety of special projects. These projects include update of old databases and development of new ones, designing an aquatic habitat evaluation program, and management of the storm-event water quality monitoring project funded as a result of the 2001 floods. This person also assists in other field and laboratory work in the water resources program.

Ongoing Program

Ongoing water resource activities for the three parks include two major efforts, and several minor ones. The major efforts are (1): water quality monitoring, primarily for fecal coliform bacteria, and (2): long-term monitoring of New River biota (LTEMS). Examples of minor efforts include reviewing Clean Water Act Section 404 and Rivers and Harbors Act Section 10 permit applications, contributing to planning efforts, coordinating with other agencies, and developing other aquatic resource efforts. Some examples of planning efforts include the New River Parkway, Sandstone Visitor Center, and National Park Service development of campgrounds and other public use areas. Examples of interagency coordination with federal agencies include consultation with the U. S. Fish and Wildlife Service and the U. S. Army Corps of Engineers regarding 404 permit applications, and the Corps of Engineers regarding alterations to Bluestone Dam and its operations. Coordination with state agencies includes West Virginia Division of Environmental Protection regarding water pollution, and West Virginia Division of Natural Resources regarding fisheries. The annual water resources budget for the three parks is approximately $225,000. This amount includes salaries, benefits, training, travel, supplies, equipment, and services (outside analysis of some water quality samples).

Baseline water-quality data have been collected in the three parks since 1980. National Park Service personnel have conducted the program since 1990. This program monitors fecal coliform bacteria and other parameters (air and water temperature, pH, specific conductance, turbidity, and dissolved oxygen). Originally collected biweekly, this sampling effort is currently operating on a monthly (or less) schedule (see below). Metals (total aluminum, iron, and manganese) and alkalinity are sampled quarterly. A Hydrolab Datasonde installed in the New River at Thurmond monitors pH, dissolved oxygen, conductivity, and water temperature every hour between April and October. These data are collected to establish baseline conditions for park waters, note trends in park water quality, and help evaluate potential influences of activities within and outside of the parks on water quality.

Water quality is evaluated regularly at 35 sites -- 25 sites within New River Gorge National River, and five each for Bluestone National Scenic River and Gauley River National Recreation Area. Of the five sites for Bluestone National Scenic River and Gauley River National Recreation Area, three for each park are on the main stem of the river, and two are on tributaries. For New River Gorge National River there are seven main stem, 16 tributary, and two spring sites. No tributary is sampled at more than one location.

In 1998 sampling frequency for baseline water quality evaluation was reduced from biweekly to monthly. Analysis of previous data showed that most samples were collected at low flows, with few samples collected during high water. Examination of the data, and a review of pertinent literature, indicated a definite hydrologic response for fecal coliform bacteria. To evaluate this response, the existing water quality monitoring was cut back, and runoff events in one stream, Dunloup Creek, were sample intensely.

The park water quality laboratory analyzes all bacteria samples collected for baseline water quality monitoring, and those collected for the Dunloup Creek Storm event sampling program, except for some that are sent to outside laboratories for quality control purposes, and most metals samples. Some metal determinations were contracted to local labs (REIC Laboratory and Analabs, Inc.) as a quality control check.

An outside laboratory analyzed water quality samples collected during the 2001 flood. This was done for two reasons. First, the New River Gorge National River laboratory suffered flood damage, and was unusable during this time. Second, the large number of samples collected each day would have overtaxed the ability of our laboratory and staff. The storm-event sampling that is now being conducted as a result of the 2001 floods is also using outside laboratories to perform the analyses.

To estimate the total load of the water quality parameters sampled, stream discharge is determined for many sites. Continuous stream flow gages (New River at Hinton, New River at Thurmond) maintained by the U. S. Geological Survey provide discharge information for New River main stem sites. Gauley River discharge is determined from U. S. Army Corps of Engineers release data for Summersville Dam. Staff gages maintained by the U. S. Geological Survey allow discharge calculations for eight tributary sites.

Several annual reports summarizing the water quality monitoring program have been produced (Wood 1990a,b,c, West Virginia Department of Natural Resources 1988, 1989a, Schmidt and Hebner 1991, Hebner 1991, National Park Service 1991, Sullivan 1992a, Gibson 1993, Sullivan 1993a,b, Wilson and Purvis 2000). The most recent report (Wilson and Purvis 2000) covers the period 1994-1997. A report covering 1998-2000 is nearing completion. Results from 1998 storm event sampling in Dunloup Creek have been presented and published (Purvis and Wilson 1999). Some of the water quality data collected during the 2001 flood event have also been published (Resource Assessment Team 2001). A report summarizing the 2002 storm-event sampling is in preparation.

Water quality monitoring for the three parks is viewed as a continuous program that should be fluid in nature to respond to changing scenarios. When the current storm event monitoring of Dunloup Creek generates sufficient data to allow reasonable interpretation, the monitoring program may change again. Whether it will revert to the previous pattern, or another tack is suggested, will depend on the situation at that time. While repeated sampling has distinct advantages, maintaining the flexibility to alter the regime as needs dictate is considered an important part of the program.

Under a NPS contract, Virginia Polytechnic Institute and State University developed LTEMS (Voshell *et al.* 1996). This program was designed to determine the effects of Bti application on, and to provide a long-term monitoring program for, New River biota. The park began LTEMS monitoring in 1991.

Historically, LTEMS has sampled five sites on the New River: Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station. The Fayette Station site was dropped in 1998 due to lack of suitable habitat and safety concerns for National Park Service employees and park visitors. The program includes collection of benthic macroinvertebrate, fish, seston, and periphyton data. Basic water quality data are also collected on each sampling date. Identification of biota, and laboratory analyses, are usually accomplished by National Park Service personnel. Some work has been contracted to outside experts and organizations.

Sampling usually occurs during the first two weeks of August each year. Thunderstorms, high water or equipment malfunction may delay onset or completion of sampling. Several habitats are sampled at each site. Fish are sampled by electofishing for thirteen 10-minute runs. Benthic macroinvertebrates are sampled from cobble-pebble and sandy pool areas, bedrock and boulders covered with riverweed, and beds of water willow using standard or especially developed equipment and techniques (Voshell *et al.* 1996). Both quantitative and qualitative samples are collected for macroinvertebrates. Quantitative samples are used to generate various community structural and functional indices (metrics). Qualitative samples are used to determine the total number of species, and their identity, existing in a given habitat. Periphyton is scraped from smooth cobbles, and seston is collected in plastic bottles held in the current.

Most fish are identified, weighed, and measured in the field, and returned to the river. Those that can't be accurately identified in the field, usually small minnows, are preserved and returned to the National Park Service laboratory for later identification. Macroinvertebrates are preserved in the field and returned to the National Park Service lab for removal from vegetation and debris ("bug picking"), sorting, and identification. Periphyton and seston samples are returned to the laboratory for chlorophyll analysis and biomass determination.

Data gathered from the monitoring program were input into a database designed specifically for LTEMS (Virginia Polytechnic Institute and State University 1994). This program, written in dBase, became unserviceable, so National Park Service personnel developed a new database in Microsoft Access. Data also are entered into Microsoft Excel worksheets to serve as a backup. A report summarizing data through 1990 has been produced (Voshell and Orth 1995), and another report summarizing more recent data was recently completed (Voshell and Orth 1999). Exhaustive statistical analysis of data through 1995 has also been completed (Smith and Marini 2000). No LTEMS data have been uploaded to STORET.

Several problems have been identified with LTEMS. As noted above, the original database program is no longer usable. Until a new database program can be developed, analyses of existing data will be slowed. Until recently there was a backlog of unidentified fishes. These fishes have now been identified, and analysis of all of the fish data collected in this program began in 2002.

The most critical problem identified with LTEMS is the time required for laboratory processing of benthic macroinvertebrate samples. Previously, an attempt was made to remove all organisms from each sample. This was extremely labor-intensive, and resulted in a serious backlog of samples collected but not yet completely processed. Identification of some samples from 1995-96 was contracted out, and this information was received in early 2002. Samples for 1997-1999 have been picked but not identified. Samples from 2000 and 2001 await picking, sorting and identification. This backlog has slowed sample analyses and interpretation, and prevents New River Gorge National River staff from undertaking other activities.

Action is being taken to alleviate the benthic macroinvertebrate sample backlog. Chief among these is subsampling. A subsampler has been constructed and is in use. This reduces the portion of each sample that must be picked, sorted, and identified. This improvement has dramatically decreased sample processing time. Subsampling should not significantly change the indices calculated to evaluate biotic changes. Some samples already picked will also be subsampled prior to identification. These samples will be used to test the impact of subsampling on community indices.

WATER RESOUCE ISSUES AND RECOMMENDED ACTIONS

This plan addresses 11 selected water resource issues. These issues evolved from a Water Resources Scoping Report (National Park Service 1996a). Each issue was categorized as high, medium, or low priority at a scoping meeting attended by interested federal, state, and local government agencies in September, 1997. To address these issues, a number of recommended actions were developed. These recommended actions will not resolve all of the water resource issues for the parks. However, they describe steps that should be taken to help resolve these issues. This plan is intended as a "living" document. As such, the parks can make appropriate revisions to the plan as more information becomes available, issues change or arise, and different or modified actions become necessary.

For the most part, the issues identified in this plan may be considered programmatic. They relate to the need for understanding park water resources, the impacts that various activities have on those resources, and the role the parks and their water resources play in the region. Addressing these issues will require expanding baseline knowledge of park water resources, long-term monitoring of those resources, developing a greater understanding of land use activities inside and outside of park boundaries, and interacting with outside entities and individuals. Addressing the issues presented in this plan requires long-term commitment and support. Expending the efforts and funds necessary to accomplish the recommended actions will provide the necessary foundation for making well informed, scientifically based, issue-oriented management decisions.

The four high priority issues are sewage pollution, water-quality data collection and management, fishery management, and *Bti* application to remove black flies. The four medium priority issues are silvicultural activities, agricultural and urban runoff, coal mining and oil and gas development, and future development. The three low priority issues are impoundments, floodplain management, and hazardous waste spills and waste sites.

Among these issues, water-quality data collection and management is unique, because it is an operational issue within the parks, rather than a land or water use that causes stress in park stream ecosystems or to other natural resources. Four recommended actions address this issue. These are:

Technical Evaluation of Water Quality Monitoring Program
Determine Streamflow Characteristics of New River Tributary Streams
Develop Long-term Monitoring Program for Gauley River National Recreation Area
Evaluate the Long-term Monitoring Program in New River Gorge National River.

Among the land- and water- use issues, pollution resulting from improper sewage disposal is clearly the greatest concern. Improper sewage disposal, both within and outside park boundaries, results in bacterial contamination of park waters, and may present a health risk to park users and employees. Three recommended actions will help managers and scientists understand the human health risks and effects of bacterial contamination in park waters. These are:

Microbial Reconnaissance of New River Gorge National River
Epidemiological Survey of Recreational Water Users in the New and Gauley Rivers
Determine Animal Sources of Fecal Bacteria in New River Tributaries.

No action is recommended to remediate improper sewage disposal. Although the need is obvious, there is no direct way for the National Park Service to directly solve this problem. Indirectly, however, the National Park Service can act to alleviate this threat. Activities such as educational programs and materials presented at visitor centers and to schools and the media are one way to work toward eliminating improper sewage disposal. Coordination with other agencies, particularly the West Virginia Department of Environmental Protection, since it has enforcement authority over water pollution, is another way. The National Park Service also can seek out, and work with, partners (e.g. National Small Flows Clearinghouse, Canaan Valley Institute, and local watershed groups) that might be able to obtain funding for remediation. For example, the National Small Flows Clearinghouse has the mission of designing and piloting effective alternative methods of sewage treatment for rural areas and small communities (National Small Flows Clearinghouse 1999). The National Park Service can offer their local knowledge and expertise, long-term bacteria data, and water quality monitoring abilities to potential partners.

With a professional aquatic ecologist and a staff of technicians, the National Park Service is well equipped to address the fishery management issues. In part due to this in-house expertise, 10 recommended actions address this issue. These are:

Historical Fisheries Data Mining
Inventory Fishes of Gauley River National Recreation Area
Inventory Fishes of Bluestone National Scenic River
Monitor Status and Distribution of Fishes in New River Gorge National River
Determine Impacts of Two Fishery Management Methods on Stream Ecosystems
Determine Diets of Exotic Trout in New River Gorge Tributary Streams
Evaluate Impacts of Exotic Trout on New River Tributary Ecosystems
Inventory Biological Resources of New River Tributaries
Outreach to Anglers on the Effects of Bait-Bucket Fish Introductions
Determine Status and Trends of New River Crayfish Community.

The application of the bacterial insecticide *Bti* to kill black flies is an issue almost as old as New River Gorge National River. Contention over this issue led to a court suit, and then to special congressional action that established the spraying program and the National Park Service's long-term monitoring of the impacts of the spraying. One action recommended under the water-quality data collection and management issue (Evaluate the Long Term Monitoring Program in New River Gorge National River) also addresses this issue. One other recommended action specifically addresses baseline information needed to examine an unexplored potential impact of *Bti* application. This action is:

Determine Status and Trends of New River Mussel Community**.**

Two recommended actions specifically address one of the medium priority issues. Several actions that address water quality data collection and management also address all medium priority issues via the monitoring of water quality to address land use impacts. The two recommended actions that are presented address the issue of mineral development. These are:

Monitor Effectiveness of Wolf Creek AMD Treatment
Determine Partitioning of Polycyclic Aromatic Hydrocarbons in Streams of the New River Watershed.

The silvicultural issue was originally prioritized as "high" largely due to concerns about possible toxic waste discharges from an oriented strand board plant in the Mount Hope area. This plant is recycling wastes instead of discharging them to area streams, so these concerns have alleviated. Also, the effects of logging are difficult to separate from those of road and other construction activities, surface mining, and other soil-disturbing activities. This makes designing an effective program for monitoring only the effects of logging operations problematic. Still, the National Park Service must remain alert for the effects of logging, and coordinate with appropriate federal and state agencies for the implementation of best management practices (BMPs) during and after logging operations.

Four recommended actions address low-priority issues. Two address the impacts of impoundments. These actions also indirectly address the floodplain management issues. These actions are:

Assess Riparian Conditions in New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area
Investigate Effects of River Regulation on Rare Plant Communities.

Two issues address the potential impacts of hazardous material spills. These are:

Determine Travel time and Dispersion of a Conservative Solute for the Gauley River in Gauley River National Recreation Area
Determine Wave Propagation for the Gauley River in Gauley River National Recreation Area.

Most of the recommended actions address high priority issues. This is prudent, given funding and personnel constraints. However, where applicable, recommendations are provided for lower priority issues. These recommendations provide the parks the ability to respond to issues if priorities shift in the future. Additionally, some of the recommended actions that address high priority issues also address, at least indirectly, lower priority issues.

The suite of recommended actions represents the concerns to the National Park Service, park users, and park neighbors. The recommended action(s) that address each issue is (are) considered the most reasonable approach at this time. This is based on a host of considerations, including National Park Service policies, public concerns, scientific evidence, technical advice of appropriate experts, and funding options.

It is important to recognize that these recommended actions constitute an ambitious program. Full implementation of this program may be beyond the current capabilities of the parks. The degree to which each project is implemented is contingent upon obtaining funding from a number of sources. Until funding is identified, the actions proposed would not be initiated, or they will be undertaken on a limited basis as staff time and other resources are available

WATER RESOURCES ISSUES

High Priority Issues

Sewage Pollution

Lack of adequate and proper treatment for human sewage and other domestic waste is the most pressing and pervasive water resource issue for the three parks. This problem is most acute in streams tributary to the New River in and near New River Gorge National River (National Park Service 1996a). Various state and Federal agencies concurred with this assessment at the issues scoping meeting.

There are several facets to this problem. Some households and communities have no septic or sewer system. In many instances existing septic systems do not function properly. In communities with sewage treatment plants (STPs), sewer lines feeding those plants are frequently broken. Also, most sewage systems in southern West Virginia combine sanitary and storm runoff into one collection system. With such a system, long or intense rain events frequently lead to inflows that exceed plant design capacity. This results in some incoming sewage being bypassed into the receiving stream. The only treatment such bypassed sewage may receive is chlorination,

Several areas near the three parks have relatively high concentrations of households without septic systems or sewer service. One such area exists in the Bluestone River watershed upstream from Bluestone National Scenic River (Figure 16). Another, similar but smaller, area exists near the confluence of New and Greenbrier Rivers just upstream from New River Gorge National River. Three such areas, which drain into New River Gorge National River, exist in Fayette County (Fayette County Water Resources Committee *et al.* 1997). One of these is the Dunloup Creek watershed. Another area is located in drainages to Keeney Creek, Manns Creek, and other tributaries to New River near the northern end of the park. The third area is the Brooklyn/Cunard area east of Oak Hill that drains into Coal Run or directly into New River.

A variety of reasons may account for the high incidence of households without any waste treatment. Among these is the physiography of the Appalachian Plateaus. Because much of the few flat areas in this region are floodplains and terraces of streams, scattered linear communities have formed along streams (Messinger 1997). Installing sewer lines in such communities is more expensive than in communities that are more concentrated. Rocky soils and dense forests in these areas further increase the cost of sewer lines. These

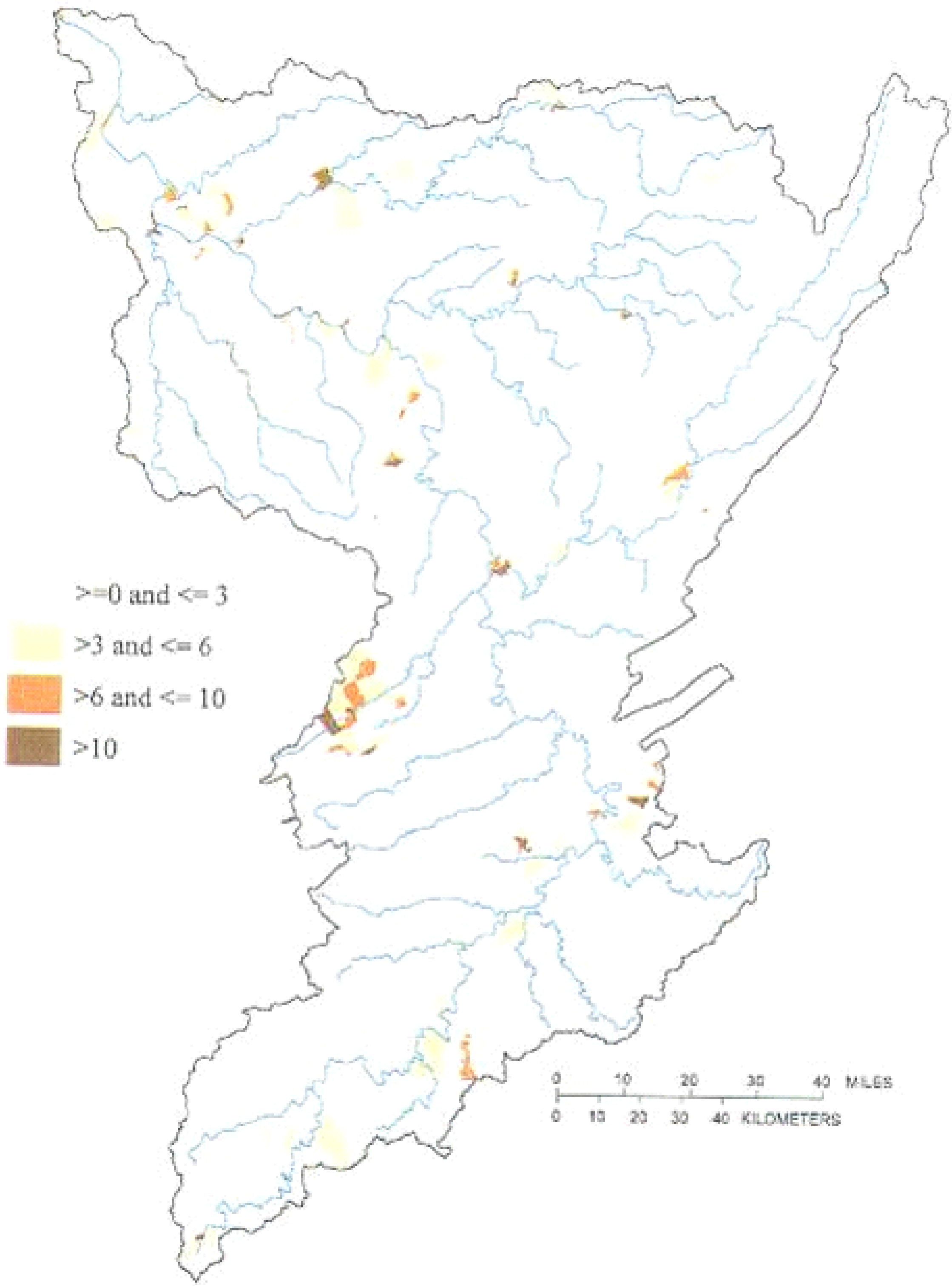


Figure 16. Number of households not served by either public Sewage systems or septic systems per square mile. After U.S. Census Bureau (1990).

problems are compounded by the area's poverty. The poverty rate in 1990 in Kanawha River Basin counties in West Virginia was 20.7 percent, compared to a National average of 13.1 percent (Appalachian Regional Commission 1999). Counties have little money available for sewage systems unless voters approve a specific bond initiative. A statewide bond initiative was passed in 1996 to provide funding for water and sewage treatment. To date, most emphasis has been given to drinking water treatment, rather than waste treatment. Given these circumstances, the problem of direct sewage discharge to streams seems likely to linger for years.

No data are available on the adequacy of existing septic systems. New, properly installed systems usually function as intended. Other systems, particularly older ones, that were not properly installed, were installed in inadequate soils, or have not been properly maintained, are usually inadequate. It is highly likely that many existing systems in the parks' watersheds fall into this category.

There are a number of sewer systems in watersheds draining into the three parks. Files maintained by the U. S. Environmental Protection Agency and the West Virginia Division of Environmental Protection list 16 sewage treatment plants permitted to discharge treated wastewater into New River or its tributaries in the vicinity of New River Gorge National River. These files also list eight plants permitted to discharge treated wastewater into Bluestone River or its tributaries in the vicinity of Bluestone National Scenic River, and no permits for Gauley River or its tributaries in the vicinity of the Gauley River National Recreation Area (Table 7).

In Fayette County, sewage dischargers into New River or its tributaries include: the town of Mount Hope and White Oak Public Service District (PSD) discharging into Dunloup Creek; the city of Oak Hill and Arbuckle PSD discharging into Arbuckle Creek; the town of Fayetteville discharging into Marr Branch; the town of Ansted discharging into Mill Creek just downstream of the park; and the town of Meadow Bridge discharging into Meadow Creek. In Raleigh County, STPs discharging into New River or its tributaries include: North Beckley PSD (eight outfalls) discharging into Piney Creek or its tributaries; the city of Beckley, Crab Orchard-MacArthur Park PSD; the town of Sophia, Stanaford Acres, Inc., and Shady Springs PSD all discharging into Piney Creek; James R. Bragg discharging into an unnamed tributary of Fat Creek (tributary to Piney Creek); and R. L. Feather, Inc. discharging into Glade Creek. In Summers County, the city of Hinton discharges into New River. Design discharges in millions of gallons per day (MGD) in the New River drainage total 0.002 for Glade Creek, 0.23 for Mill Creek, 0.5 for Marr Branch, 0.138 for Meadow Creek, 0.7 for Arbuckle Creek, 1.1 for Dunloup Creek, 0.625 for New River, and over 6.1 for Piney Creek.

In Mercer County, sewage dischargers into Bluestone River or its tributaries include: Bluewell PSD, Green Valley-Glenwood PSD, and the city of Princeton discharging into Brush Creek; the city of Athens discharging into Laurel Creek; Bramwell PSD discharging into Bluestone River; the town of Matoaka discharging into Widemouth Creek; and Mr. Paul Canterberry discharging into an unnamed tributary of Christians Fork of Brush Creek. Oakvale Road PSD in Raleigh County sends its wastewater to Princeton for treatment. In Summers County, True Wetlands, Inc. discharges to an unnamed tributary to Tony Hollow (tributary to Bluestone River). Design discharges in

Table 7. NPDES permitted discharges of treated wastewater in vicinity of parks.

Site	NPDES Number	Receiving Stream	Design discharge (million gallons/day)
New River Drainage			
Town of Ansted	WV0020672	Mill Creek	0.23
Arbuckle PSD	WV0027022	Arbuckle Creek	0.4
Town of Fayetteville	WV0022314	Marr Branch	0.5
Town of Meadow Bridge	WV0082261	Meadow creek	0.138
Town of Mount Hope	WV0021776	Dunloup Creek	0.31
City of Oak Hill, Plant 2	WV0020281	Arbuckle Creek	0.3
White Oak PSD	WV0044041	Dunloup Creek	0.75
City of Beckley	WV0023183	Piney Creek	3.5
Crab Orchard-MacArthur PSD	WV0082309	Piney Creek	1.0
James R. Bragg	WV0084531	Unnamed tributary to Fat Creek	0.039
North Beckley PSD	WV0027740	Piney Creek and its tributaries	0.56
R.L. Feather, Inc.	WV0103624	Glade Creek	0.002
Town of Sophia	WV0024422	Piney Creek	0.25
Stanaford Acres, Inc.	WV0084824	Unnamed tributary to Piney Creek	0.02
Shady Springs PSD	WV0080403	Piney Creek	0.8
City of Hinton	WV0024732	New River	0.625
Bluestone River Drainage			
City of Athens	WV0020338	Laurel Creek	0.25
Bramwell PSD	WV0041971	Bluestone River	0.1
Bluewell PSD	WV0028134	Brush Creek	0.4
Green Valley-Glenwood PSD	WV0082627	Brush Creek	1.5
Town of Matoaka	WV0024864	Widemouth Creek	0.075
Mr. Paul Canterberry	WV0043885	Unnamed tributary to Christians Fork of Brush Creek	0.03
Oakvale Road PSD	WV0080489	City of Princeton	---
City of Princeton	WV0023094	Brush Creek	3.6
True Wetlands, Inc.	WV0104957	Unnamed tributary to Toney Hollow	0.0019
Gauley River Drainage – no sites			

the Bluestone drainage total 0.25 MGD for Laurel Creek, 0.075 MGD for Widemouth Creek, 0.1 for Bluestone River, and over 5.5 MGD for Brush Fork.

Many of the above-listed STPs experience problems during periods of excessive storm runoff. Several of the systems are fed by combined sewer overflow systems. In these systems, sewer lines and storm drains are combined into one collection network. This type of system frequently experiences problems during storm events. When inflow to the STP exceed the interceptor or regulator capacity, the excess flow is discharged directly to the receiving stream, often without treatment. The cities of Beckley, Hinton, and Princeton are currently listed by the West Virginia Division of Environmental Protection as combined sewer overflow systems. In 1998 that agency began an investigation into whether the town of Fayetteville should be added to this list (Tom Marshall, West Virginia Division of Environmental Protection, personal communication 1998 and 1999).

Combined sewer overflow systems must comply with a nine-point program designed by EPA to reduce waste loads discharged to streams. The nine minimum controls (U. S. Environmental Protection Agency 1995) are as follows:

1. Proper operation and regular maintenance programs for the sewer system and combined sewer overflow outfalls
2. Maximum use of the collection system for storage
3. Review and modification of pretreatment requirements to ensure that combined sewer overflow impacts are minimized
4. Maximization of flow to the treatment facility for treatment
5. Elimination of combined sewer overflows during dry weather
6. Control of solid and floatable materials in combined sewer overflows
7. Pollution prevention programs to reduce contaminants in combined sewer overflows
8. Public notification to ensure that the public receives adequate notification of combined sewer overflow occurrences and impacts
9. Monitoring to effectively characterize combined sewer overflow impacts and the efficacy of combined sewer overflow controls.

Systems with separate storm and sanitary collection networks may also experience overloads during wet periods. This is due to excessive inflow and infiltration (I&I) into the collection system. Inflow is surface water entering sewer systems through roof and storm drains, drop inlets, defective manhole covers, and other pipe openings during and after a storm. Infiltration is ground water entering a sewer system through broken or cracked pipes, misaligned joints, abandoned or faulty laterals, manhole walls, or other underground openings. Excessive I&I to sewer lines may create hydraulic overloads at treatment plants similar to those noted above for combined systems.

Permit files at the West Virginia Division of Environmental Protection, Office of Water Resources indicate that excessive I&I occurs in many sewer systems in drainages to New River Gorge National River and Bluestone National Scenic River. Field inspections of treated wastewater discharges in the New River drainage have noted excessive I&I at White Oak PSD, the city of Oak Hill, the town of Mount Hope, Arbuckle PSD, the town of Fayetteville, Shady Springs PSD, and the town of Sophia. Similar problems have been noted at Bluewell PSD, the town of Matoaka, and the city of Athens in the Bluestone River drainage.

Another possible source of human waste is that removed from drinking water by water treatment plants. This waste is sometimes discharged back to streams by small water treatment plants in Fayette County (Allen Parsley, West Virginia American Water Company, personal communication 2000). This problem has been noted in Mill Creek in the Ansted area, downstream from New River Gorge National River. Currently there are 21 water treatment plants in Fayette County. The Fayette Plateau Regional Water System to be constructed in Fayette County will replace eight of these plants with one regional plant. The regional plant will not discharge waste back into streams, but dispose of it in storage lagoons. Plant closings should reduce this source of human waste to streams. The impact of improperly, inadequately, or non-treated human sewage in water bodies is frequently diagnosed by the use indicator bacteria. These bacteria (actually a group of bacteria) are fecal coliform bacteria. These bacteria live in the intestinal tracts of warm-blooded animals, and are excreted with their feces (Britton and Greeson 1988). Fecal coliform bacteria are not harmful, but they do indicate the presence of fecal wastes. Fecal wastes often contain human pathogens, including other bacteria, viruses, and protozoans. Therefore, higher concentrations of fecal coliform bacteria in surface waters indicate higher probabilities that pathogens also may be present.

The West Virginia standard for water contact recreation is based on fecal coliform bacteria. The criterion for this standard is that the count shall not exceed 200 fecal coliform colonies per 100 milliliters of water. This criterion is based on the geometric mean of at least five samples per month. Alternately, the sample should not exceed 400 colonies per 100 milliliters in more than 10 percent of all samples taken during one month (West Virginia Environmental Control Board 1995).

Several New River tributaries (Figure 17, Table 8) frequently have high densities of fecal coliform bacteria (West Virginia Division of Natural Resources 1989a, Wood 1990a, 1990b, National Park Service 1991a, 1991b, 1993b, 1993d, Purvis and Wilson 1999, Wilson and Purvis 2000). Maximum measured fecal coliform densities (colonies/100 ml) for the period 1985 to 1997 include >95,000 in Arbuckle Creek, >940,000 in Marr Branch, 30,000 in Madam Creek, 40,000 in Keeney Creek, >22,000 in Dunloup Creek, 140,000 in Piney Creek, 4,333 in Coal Run, and >10,000 in Wolf Creek.

Median concentrations of fecal coliform bacteria for the period 1994 to 1997 (Table 9) were highest in Madam, Keeney, and Arbuckle Creeks, followed by Marr Branch, Dunloup Creek, Piney Creek, and Coal Run (Wilson and Purvis 2000).

Median fecal coliform bacteria densities for all samples collected by the NPS in 1997 exceeded 200 colonies/100 ml in four streams (Table 9). Median fecal coliform densities exceeded this standard for 8 of 8 years at Keeney and Madam creeks, 8 of 9 years at Marr Branch, 8 of 10 years at Arbuckle Creek, 9 of 12 years at Dunloup Creek, 6 of 12 years at Piney Creek, and 2 of 4 years at Coal Run. All remaining sites, including both tributary and New River main-stem sites, had at least one sample that exceeded 200 colonies per 100 milliliters.

Table 8. Selected National Park Service water quality sampling sites as shown in Figures 17, 18, and 19. M and T refer to main stem and tributary, respectively.

NEW RIVER GORGE NATIONAL RIVER	
1-M	New River at Hinton, NERI Visitor Center
2-T	Madam Creek near the Mouth
3-M	New River at Sandstone Falls
4-M	New River at Sandstone
5-T	Lick Creek at Stream Gage Site
6-T	Meadow Creek at Stream Gage Site
7-T	Laurel Creek at Quinnimont
8-M	New River at Prince
9-T	Piney Creek at McCreery
11-T	Dunloup Creek at Stream Gage Site
12-M	New River at Thurmond
13-T	Arbuckle Creek near the Gage Site
14-M	New River at Cunard
15-T	Coal Run near Cunard
16-T	Keeney Creek at Winona
17-M	New River at Fayette Station
18-T	Wolf Creek at Fayette Station
19-T	Marr Branch below Rivers, Inc., Campground
BLUESTONE NATIONAL SCENIC RIVER	
1-M	Bluestone River near Bluestone State Park
2-T	Little Bluestone River
3-M	Bluestone River near Confluence
4-M	Bluestone River at Pipestem State Park
5-T	Mountain Creek at Pipestem State Park
GAULEY RIVER NATIONAL RECREATION AREA	
1-M	Gauley River at Summersville Dam
2-M	Gauley River at NARR Campsite
3-T	Peters Creek near Mouth
4-M	Gauley River at South Side Swiss
5-T	Meadow River above the Mouth of Stickley Run

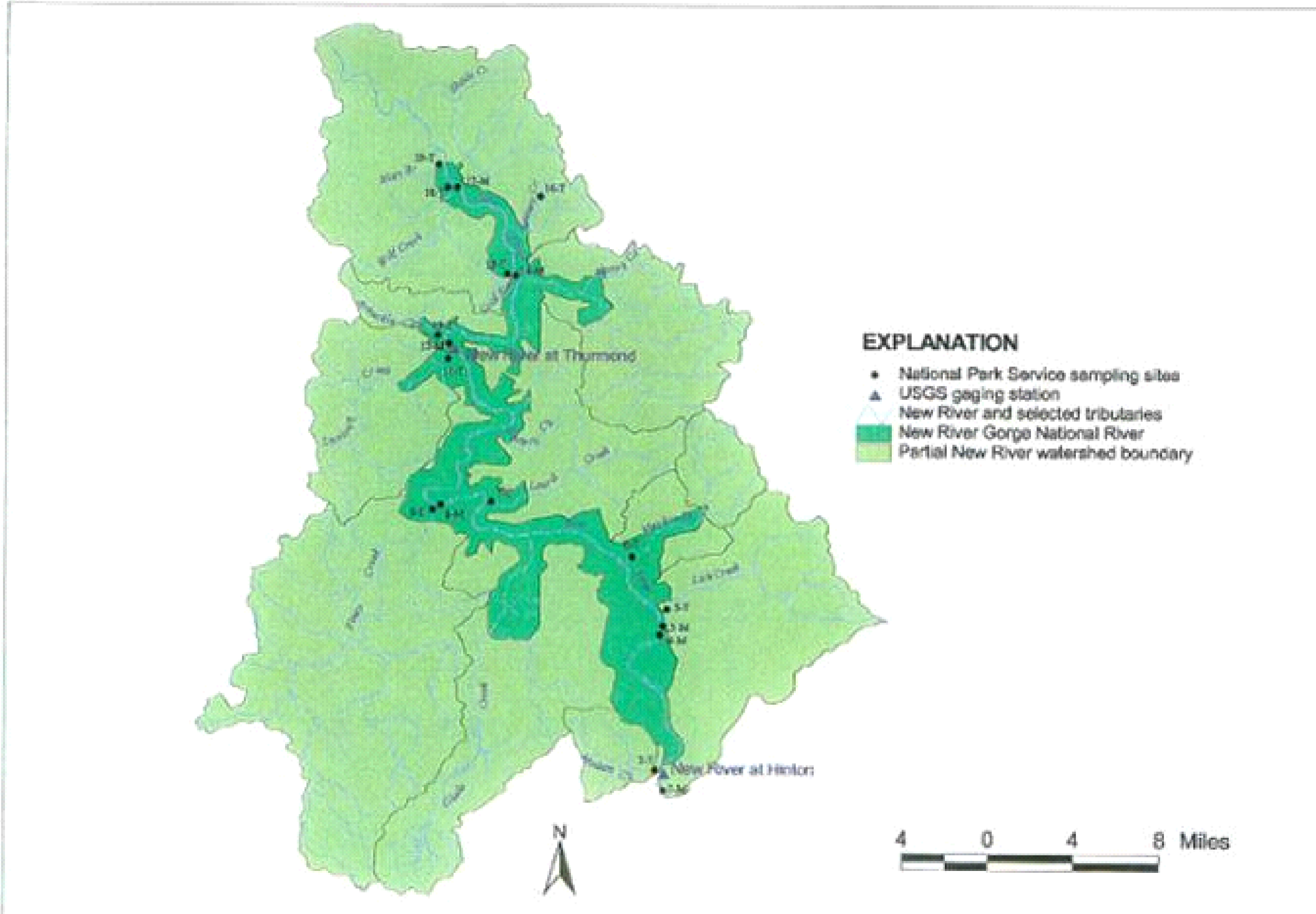


Figure 17. New River Gorge National River and selected park sampling sites. See Table 8 for station code definitions.

Table 9. Maximum and median fecal coliform concentrations for 1994 to 1997 for National Park Service bacteria sampling sites in or near the New River Gorge National River. [Tabulated from data in National Park Service files, Glen Jean, West Virginia.]

Sampling Site	Maximum Concentration of Fecal Coliforms (colonies/100 ml)				Median Concentration of Fecal Coliforms (colonies/100ml)			
	1994	1995	1996	1997	1994	1995	1996	1997
Arbuckle Creek	3,920	74,200	8,440	2,650	280	165	700	380
Coal Run	1,200	1,055	1,200	1,240	148	108	270	246
Dunloup Creek	880	1,160	510	626	238	140	235	176
Keeney Creek	9,800	13,800	4,140	4,700	2,662	1,600	875	560
Laurel Creek at Quinnimont	264	470	290	109	9	16	192	43
Lick Creek	9,475	1,705	186	360	76	50	62	75
Madam Creek	21,400	10,880	9,160	9,020	5,450	840	3,515	3,080
Marr Branch	91,000	5,700	2,040	2,490	2,100	275	560	133
Meadow Creek	6,000	2,320	650	2,004	54	62	108	83
New River at Sandstone Falls B	1,100	245	190	98	53	18	50	19
New River at Sandstone Falls PK	2,060	310	326	490	41	12	46	23
New River at Cunard	353	802	320	165	20	20	64	17

Table 9. Continued.

Sampling Site	Maximum Concentration of Fecal Coliforms (colonies/100ml)				Median Concentration of Fecal Coliforms (colonies/100ml)			
	1994	1995	1996	1997	1994	1995	1996	1997
New River at Fayette Station	160	944	470	233	18	24	92	14
New River at Hinton VC	310	375	124	842	46	28	34	33
New River at Prince	216	480	1,200	820	20	24	106	18
New River at Thurmond	236	844	480	332	24	22	92	8
Piney Creek at McCreery	9,900	2,800	22,200	4,575	139	68	5,205	110
Wolf Creek	2,000	764	2,100	138	54	44	113	31

Fecal coliform bacteria densities in New River are usually low when compared to tributary samples taken at the same time. This is because the high flow of New River dilutes high bacteria densities received from tributaries, or receives the tributary inflow after the dieoff of the majority of the fecal coliform bacteria. Occasionally, however, fecal coliform densities in New River will be high. This occurs most often when samples are collected a short distance downstream from the inflow of a contaminated tributary. Tributary waters may not fully mix into the receiving stream for hundreds of feet or even miles, particularly in the case of a major tributary at high flow mixing into a receiving stream at low flow. New River densities also increase during high flow events. Densities in tributaries are usually very high during storm events, and this increased input, combined with the rapid velocity of New River during high flows, contribute to these increased densities.

Samples collected by the National Park Service for Bluestone and Gauley Rivers between 1994 and 1997 (Figures 18 and 19, Table 8) also revealed some relatively high bacteria densities (Wilson and Purvis 2000). The highest densities (colonies/100 ml) for Bluestone National Scenic River sampling sites were: Bluestone River at Pipestem (4,325 in 1995), Bluestone River at confluence (3,580 in 1995), Bluestone River at Bluestone State Park (3,400 in 1995), and Mountain Creek (1,310 in 1994). The highest densities for Gauley River National Recreation Area sites came from Peters Creek. Densities measured 1,250 and 1,030 in 1994, 9,000 and 1,180 in 1996, and 1,140 in 1997.

Improvements to sewage treatment facilities and collection systems can have major positive impacts on the water quality of discharges to, and surface water in, area streams and rivers. Water quality, as measured by fecal coliform bacteria densities, showed dramatic improvement after completion of a new STP by the city of Hinton in July 1991. Fecal coliform bacteria counts in New River downstream from this plant decreased by several orders of magnitude. Similar improvements have been noted in Marr Branch.

Fecal coliform bacteria are not the only indicator bacteria. Francy *et al.* (1993) concluded that fecal bacteria types such as *E. coli* and enterococci are more reliable indicators of the risk for water-based recreation in contaminated waters. The U. S. Environmental Protection Agency has long recommended that state regulations for water contact recreation be based on *E. coli*, instead of fecal coliform concentrations (U. S. Environmental Protection Agency 1986, 1999a).

The relation between concentrations of indicator bacteria and pathogens is not thoroughly understood. This concern is addressed by the recommended action: **Microbiological Reconnaissance of New River Gorge National River**. Likewise, little is known about the relation between the concentrations of indictor bacteria or pathogens and the outbreak of disease. This concern is addressed by the recommended action: **Epidemiological Survey of Recreational Water Users in the New and Gauley Rivers**. Some local citizens have opined that dense populations of deer and other animals in the New River watershed may be a major contributor to fecal pollution. This concern is addressed by the recommended action: **Determine Animal Sources of Fecal Bacteria in New River Gorge National River Tributaries.**

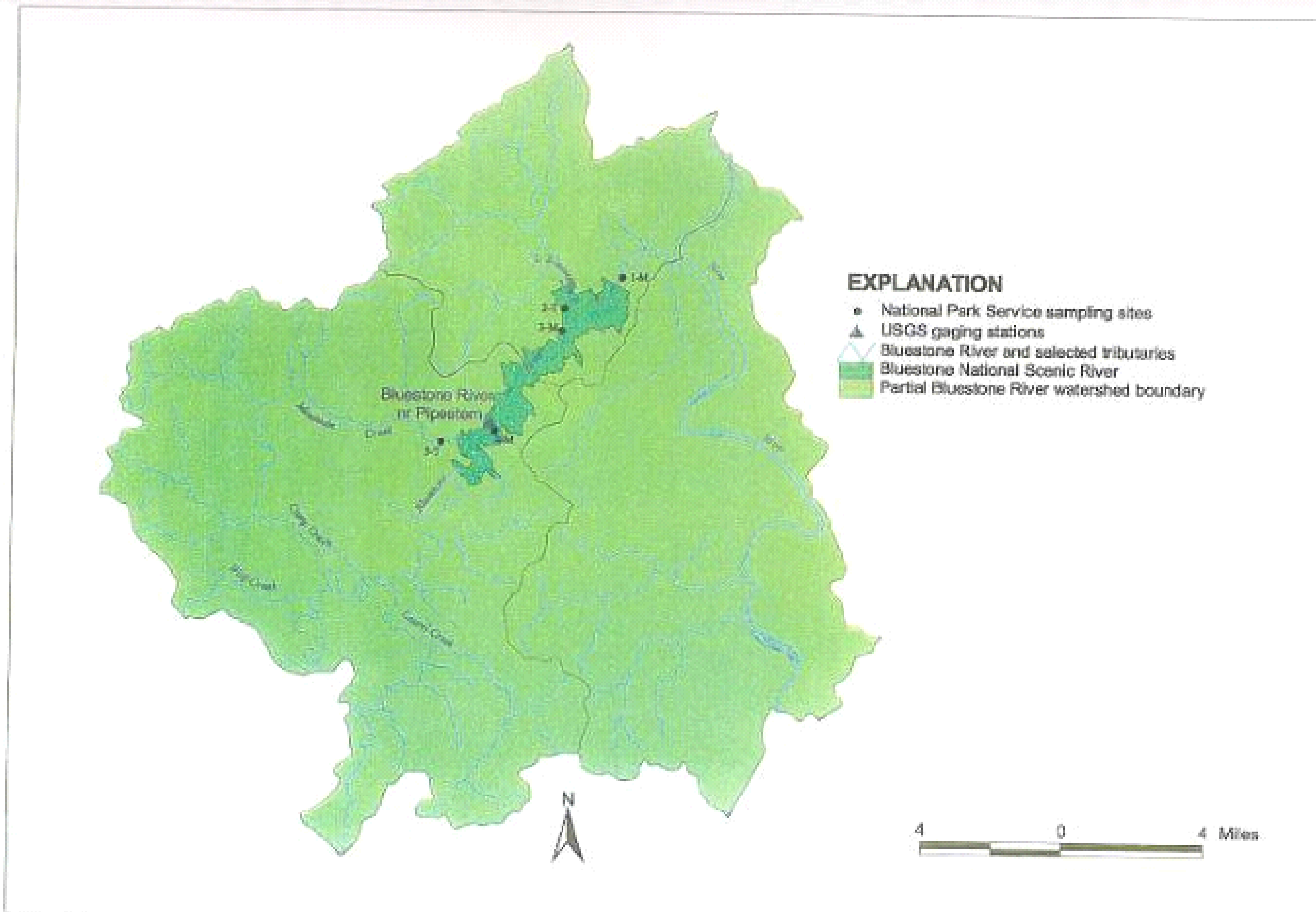


Figure 18. Bluestone National Scenic River and selected park sampling sites. See Table 8 for station code definitions.

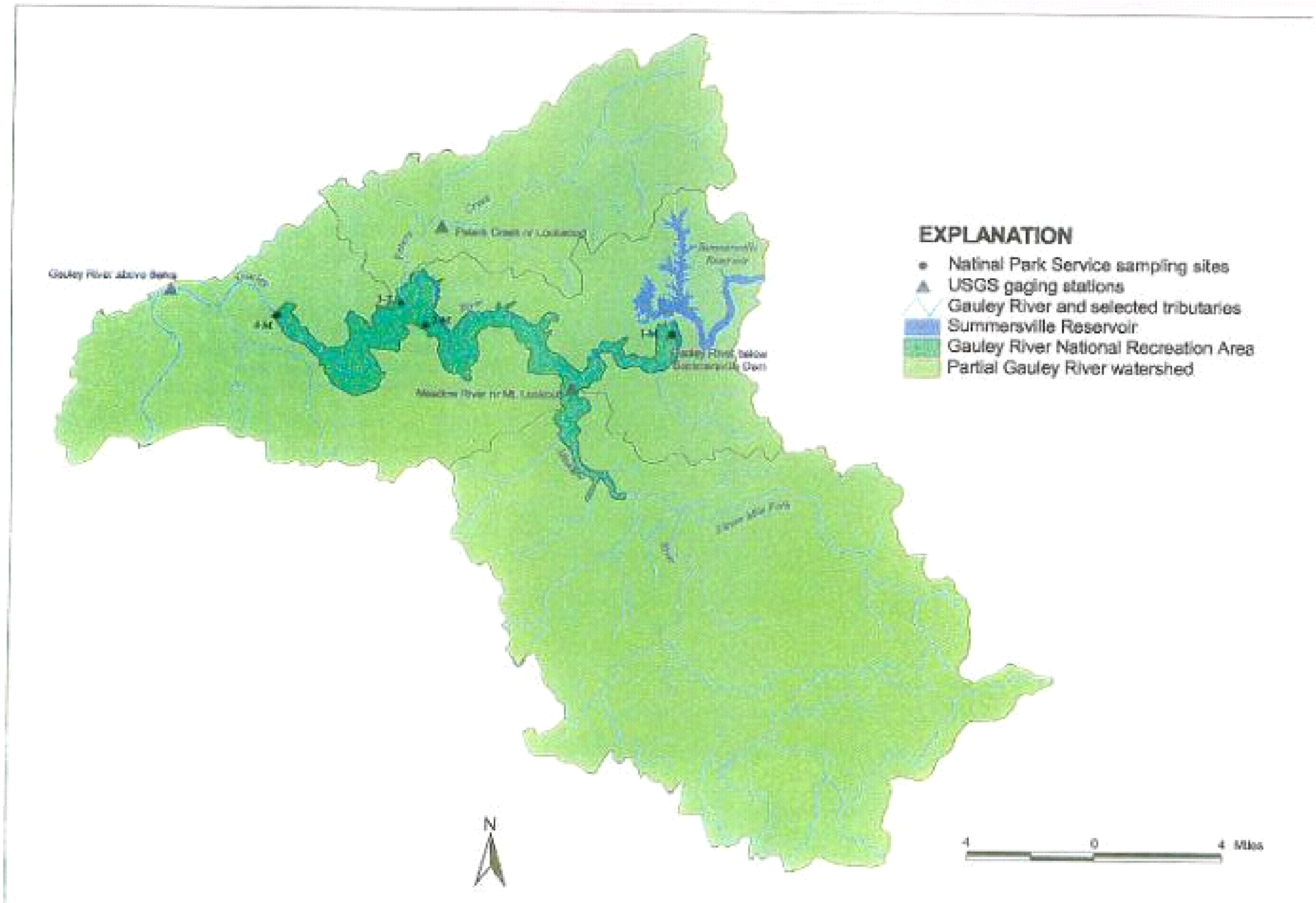


Figure 19. Gauley River National Recreation Area and selected park sampling sites. See to Table 8 for station code definitions.

Water Quality Data Collection and Management

Since Bluestone National Scenic River, New River Gorge National River, and Gauley River National Recreation Area are all river-based units of the National Park system, it is very important that the National Park Service have good water quality information. This information must be gathered in an organized, meaningful way. Additionally, this information must be readily accessible. This is true not only for the National Park Service so that well-informed, scientifically based management decisions can be made, but also so that other entities and the public can understand the state of park resources.

The parks have accumulated a substantial amount of useful water quality data. The bacteria and baseline monitoring program has been helpful in establishing the magnitude of the land- and water-use issues affecting park management. Despite this, there are shortcomings that exist in the parks' water quality monitoring program. The recommended action **Technical Evaluation of Water Quality Monitoring Program** addresses these concerns.

Historically, water quality monitoring in the three parks has been conducted on a relatively regular schedule. This sampling regime has generated a considerable amount of baseline data. However, water quality is strongly influenced by the hydrologic cycle. Water quality during high flows caused by storm events and snowmelt runoff is often quite different from that observed under baseflow conditions. The National Park Service has begun to address this issue, but more efforts in this direction are warranted.

In order for water quality monitoring to be considered accurate and valid, standard methods of collection and analysis must be used. Standards for quality assurance (QA) and quality control (QC) must also be observed. While the parks presently observe these standards, this effort should be a more important and visible component of water-quality monitoring program.

The parks have collected water-quality data since 1980. Parameters measured have included fecal coliform bacteria, temperature, specific conductance, pH, dissolved oxygen, alkalinity, nutrients, major cations and anions, and metals. Sites and constituents have varied over the period of monitoring. Data collected from the monitoring program are entered into spreadsheets and databases, and some of this data has been input to the U. S. Environmental Protection Agency's STORET database. Data from the monitoring program are analyzed and evaluated, and this work is made available to the public and interested entities in the form of water quality publications. A history of water-quality monitoring in the three parks is provided in the following paragraphs.

Water-quality monitoring of the park units began in 1980 when the National Park Service recruited the West Virginia Division of Natural Resources to monitor sites in New River Gorge National River to establish baseline conditions. Data was collected for such constituents as fecal and total coliform, temperature, specific conductance, pH, dissolved oxygen, biochemical oxygen demand (BOD), alkalinity, nutrients such as nitrogen and phosphorous, major cations and anions, and metals. This information was collected from six main stem and nine tributary sites for the period 1980 to 1984 (Wood 1990a).

Using the above baseline data, and recognizing fecal waste as being the chief water quality problem in the park, the National Park Service developed a fecal coliform bacteria monitoring plan for 1985-86 for the New River Gorge. This plan included 12 collection sites on the main stem of New River and eight sites on tributaries (Wood 1990a). In 1985 park personnel analyzed the bacteria samples using quick and inexpensive Coli Counters. This method was not U. S. Environmental Protection Agency-approved. Beginning in 1986, bacteria data were analyzed by the U. S. Environmental Protection Agency-approved membrane filter (MF) technique. The U. S. Department of Agriculture's Appalachian Soil and Water Research Laboratory in Beaver, WV analyzed these samples. The data for 1985 to 1986 are published in Wood (1990a).

In 1987 the parks returned responsibility for water-quality monitoring to the West Virginia Division of Natural Resources. Fecal coliform samples were collected at nine main stem sites and five tributary sites in 1987, and at nine main stem sites and six tributary sites in 1988 (West Virginia Department of Natural Resources 1989a). In 1989 the West Virginia Division of Natural Resources collected and analyzed water samples for six main stem and ten tributary sites in New River Gorge National River. In addition to fecal coliform, other parameters measured included total iron, manganese, and aluminum, sulfate, dissolved solids, suspended solids, temperature, dissolved oxygen, specific conductance, and pH. This work (Wood 1990b) noted high bacteria concentrations downstream of the Hinton sewage treatment plant on New River.

In 1990 the National Park Service again took responsibility for water quality monitoring. Bacteria samples collected in 1990 were analyzed at the U. S. Department of Agriculture laboratory. In 1991 a dedicated water quality laboratory had been completed at park headquarters. Beginning that year, bacteria samples, collected in sterile bottles and transported on ice, have been analyzed at that laboratory.

In 1990 fecal coliform densities, temperature, pH, specific conductance, and dissolved oxygen were determined at six main stem sites and 13 tributary sites (National Park Service 1991a). In 1991 the park collected data for fecal coliform, temperature, pH, dissolved oxygen, and specific conductance at six main stem sites and 13 tributary sites in New River Gorge National River (National Park Service 1991b). Similar data were also collected at three main stem sites and one tributary site in each of Bluestone National Scenic River and Gauley River National Recreation Area (National Park Service 1991c). In 1992 the park collected data for the same constituents plus alkalinity and total iron, manganese, and aluminum at seven main stem and 11 tributary sites in New River Gorge National River (National Park Service 1993b). Similar data were also collected at three main stem and two tributary sites in both Bluestone National Scenic River and Gauley River National Recreation Area (National Park Service 1993c). In 1993 (National Park Service 1993d) the same constituents and sites were collected as had been done in 1992. Similar sites and constituents were sampled between 1994 and 1997 (Wilson and Purvis 2000), and between 1998 and 2000 (Wilson and Purvis, in preparation), and again in 2001.

The National Park Service monitors fecal coliform bacteria because the West Virginia sanitary water quality standard for water contact recreation is based on this parameter (West Virginia Environmental Control Board 1995). Scientific evidence suggests that *E.*

coli is a superior indicator for this purpose (Cabelli *et al.* 1979). This epidemiological survey of a Lake Erie beach found that *E. coli* densities correlated more closely with gastric disturbance following swimming than did fecal coliform densities, although the correlation to *E. coli* densities was weak. The U. S. Environmental Protection Agency has long recommended the use of *E. coli*, rather than fecal coliforms, for this purpose (U. S. Environmental Protection Agency 1986, 1999a). The National Park Service has analyzed some samples for *E. coli*, and some simultaneous comparison sampling for *E. coli* and fecal coliform has occurred.

Methods for directly measuring pathogens, as opposed to indicators, have been developed in recent years. These methods hold promise for use to directly determine health risks to park visitors. A pilot project completed under agreement by the U. S. Geological Survey in 2001 investigated some of these methods. The draft report of this work has been submitted to the National Park Service for review, and a final report is expected in the near future. A more in-depth evaluation of these techniques is highly desirable. This is proposed as the recommended action: **Microbiological Reconnaissance of New River Gorge National River**.

Determining the incidence of water-borne diseases among river users in the three parks, and relating this information to indicator (or pathogenic) bacteria, is the only way to positively relate bacterial conditions to human health. This kind of work also could help to validate or discredit the U. S. Environmental Protection Agency guidance on indicator bacteria. These issues are addressed in the recommended action: **Epidemiological Survey of Recreational Water Users in the New and Gauley Rivers**.

The parks' bacteria sampling program does not meet West Virginia regulatory guidelines for determining violations of standards. The state standard is based on a geometric mean of at least five samples within a one-month period. Except for special monitoring programs, like storm event monitoring, the National Park Service rarely samples a given site more than once or twice a month. Sampling with greater frequency might be more useful for enforcement purposes. This would permit an accurate determination of whether the actual letter of the state standard had been violated. Making such a change in the program is not presented as a recommended action. Making such a change would be a policy decision at the level of senior Park management. Because the water resources staff is already stretched thin, increasing the frequency of monitoring would require decreasing other efforts.

Another area in which the bacteria monitoring program could be improved would be to consider hydrologic variation in the sampling design. Bacteria are suspended, not dissolved, in stream water. Thus they are transported like suspended sediment rather than a dissolved constituent. The concentration of suspended sediment varies across the cross section of the stream channel, being greatest where current velocity is the greatest. Taking this variation into account will result in samples that are more representative of the entire stream (Edwards and Glysson 1988).

Suspended sediment and bacterial movement in a watershed, and input to streams in the watershed, is complex. Bacteria from nonpoint sources (e.g. feedlots and pastures, lawns and golf courses, developed areas, and wildlands like forests) are flushed into streams by the first rain to fall during a storm, and are transported with overland flow on the rising limb of a hydrograph (Elder 1987). Bacteria from septic systems may either be flushed into a stream during a storm, or they may enter a stream relatively constantly. The pattern of input depends on the quality and condition of the septic tanks and leach fields. Bacteria from straight pipes and sewage treatment plants enter a stream in pulses that are independent of streamflow. Increases in flow in these streams may dilute already-high concentrations of bacteria. Because of this complexity, and because tributary watersheds within the three parks contain a variety of fecal bacteria sources, understanding streamflow is essential in order to design representative sampling, and to permit accurate interpretation of the bacteria data. Stream discharge is determined for most sites by either direct measurement (e.g. releases from Bluestone and Summersville Dams), or from U. S. Geological Survey-maintained gauging stations. A few of the tributary streams do not have gaging stations. Discharge in these streams is categorized qualitatively (low, normal, or high). Only two gauging stations (New River at Hinton and New River at Thurmond) provide continuous discharge data. Because of the frequent high densities of fecal coliform bacteria in many tributary streams, establishing continuous stream gages on one or more of these streams in highly desirable. This issue is addressed in the recommended action: **Determine Stream Flow Characteristics of New River Tributary Streams**.

All water-quality data collected for the period 1980 to 1994 are stored in the U. S. Environmental Protection Agency's STORET database (U. S. Environmental Protection Agency 1999d). After the park completes creation of a new in-house database, data collected since 1994 will be input to STORET.

Within the park, data for 1980 to 1993 have been stored in dBase IV files. These files are old and inefficient, and park staff noticed several problems. Data collected since 1994 are stored in Microsoft Excel spreadsheets. New River Gorge National River staff have recently created a database in Microsoft Access for all water quality data for the three parks. Maintaining one database at park headquarters for all water-quality data is the most preferable choice in terms of data-management efficiency. Of course paper copies of all data are also maintained, and a fireproof filing cabinet has been acquired to keep these records. Implementation of a geographic information system (GIS) at park headquarters will allow water-quality data to be matched with land use and other factors.

The park also runs LTEMS (Voshell *et al.* 1990b). This effort is described in detail under the issue ***Bti* application to remove black flies**. While not its designed purpose, this program does collect basic water quality data. Another water quality aspect of this program is its design to determine biological health of New River. Data from this effort is input to a dedicated database program. The original program was written in dBase, and developed a number of problems. Park staff developed a new database and all of the existing data are now in this new database. At this writing, a manual describing this new database and its use is in preparation. Another problem with this program was a serious backlog of benthic macroinvertebrate samples. The implementation of a subsampling program has made significant inroads into this backlog. Since the park is addressing these problems, no specific recommended actions are necessary.

The LTEMS program only addresses the main stem of New River. Only four sites are sampled and then only once a year. Such a sampling regime may overlook important phenomena occurring at other places within New River or at times other than those sampled. In a large stream such as New River, these may be important issues. These issues are addressed in the recommended action: **Evaluate the Long Term Monitoring Program in New River Gorge National River**.

No long term monitoring of aquatic biological resources occurs in Bluestone River or Gauley River, or in any of their tributaries. In fact, basic information on aquatic biological resources is lacking for these streams. Because it receives the heaviest use after New River Gorge National River, development of basic aquatic biological information and implementation of a plan for long term monitoring of these resources should be a high priority. This issue is addressed in the recommended action: **Develop Long-term Monitoring Program for Gauley River National Recreation Area**. Acquiring basic information from tributary streams is addressed under the **Fishery Management** issue. While obtaining similar information about Bluestone National Scenic River is also highly desirable, low use and staff constraints do not warrant the presentation of a recommended action at this time.

A rigorous QA/QC program is necessary in every data collection effort to prove its validity. Analysts and collectors should view QA/QC measures as an opportunity to prove to others, in a quantifiable way, their professionalism and the quality of their work. A QA/QC should not stand alone as a separate project, but should be incorporated into the overall project design. Within USGS, QA/QC should use about ten percent of a project's budget and effort (Shampine *et al.* 1992). QA/QC for water-chemistry sampling should include field and laboratory blank (negative control), replicate, and matrix-spike (positive control) samples. Field QA/QC for biological collecting should be based on replicate sampling through time, between multiple reaches at a stream site, and within a single sampling reach. If more than one field crew collects samples on a given project, it is especially important for the multiple field crews to independently collect replicate samples in the same reach to establish between-crew variability. Measuring and recording flow and electrical conductance of the stream is an important component of QA/QC for fish collecting, because electrofishing efficiency is flow-dependent. Laboratory QA/QC for biological collections should include split sample analysis (when subsampling is used), in addition to archiving voucher specimens and validation of identifications by another recognized expert.

The National Park Service observes basic QA/QC in the design and implementation of its water quality and long-term biological monitoring program. For example, meters are calibrated daily, and if a malfunction is noted or suspected in the field their use is stopped and notes made on the field data sheets. Duplicate samples for bacteria enumeration are often collected, with one sample analyzed by the National Park Service and the other analyzed by an outside laboratory. The National Park Service needs to make their QA/QC procedures more formalized, and document these procedures. Since this is an operational issue within the park, no formal recommendation is presented at this time.

Fishery Management

Half of the fish species, and most of the game fish species, in the New River system, have been introduced (Jenkins and Burkhead 1994). Damage to natural systems by introduced animals is cause for much concern (Li and Moyle 1993). These introductions commonly sacrifice sustainable benefits for short-term gains. Species introduction is a type of perturbation that, if successful, alters the biotic community into which the species is introduced. For example, changing a system's top predator has been shown to influence species presence and abundance patterns and food web dynamics at lower levels (McPeek 1998). Therefore it is important to understand the effects introduced species can have on native species and ecosystems. Without such understanding, well-intentioned management programs can create problems that actually subvert the original intention of the action.

The first step in determining the impacts of species introductions on natural ecosystems is to determine what species already exist in those systems. A great deal is known about the status of fish species in New River (Table 5). Less is known about fish species in Gauley River, and even less about fish species in Bluestone River. Likewise, little is know about fishes in tributary streams within the three parks. The National Park Service needs to acquire as much of this existing information as possible. Since much of this information is in the form of agency files rather than published reports, this concern is addressed by the recommended action: **Historical Fisheries Data Mining**.

The National Park Service funded a baseline survey of fishes in streams tributary to New River within New River Gorge National River during 2001. Since some of the streams sampled in 2001 were severely impacted by that year's floods, some of these streams will be re-sampled in 2002. A progress report on this work has been received, and the final report should become available after analysis of the data from the re-sampled sites. Similar baseline surveys are proposed for the main stems of Gauley River and Bluestone River as part of the National Park Service's Inventory and Monitoring Program. These projects are included as the recommended actions: **Inventory Fishes of Gauley River National Recreation Area** and **Inventory Fishes of Bluestone National Scenic River.** The work described in these two proposals may be accomplished under one combined contract/agreement.

Baseline inventories only cover a short period of time. Because natural populations and communities are dynamic, they need to be monitored over a long time period. This will allow for determining trends in populations and communities. This concern is addressed by the recommended action: **Monitor Status and Distribution of Fishes in New River Gorge National River**.

Determining the impacts of introduced species is very complex. Each species has what is called a niche. This niche is the role, or function, that the species plays in the ecosystem. The niche of a species has multiple dimensions. These dimensions take into account such factors as food-web relationships, habitat usage, and population dynamics. Each of these factors, in turn, is also very complex. Additional complexity is added due to changes in niche dimensions over time and seasons, and due to interactions with the environment and other species present in the ecosystem. Because of this niche complexity it is nearly impossible to determine ahead of time what impacts an introduction will have on the existing ecosystem.

Frequently, rationale for intentional introductions is based on a so-called vacant niche. This vacant niche is usually described in terms of an abundant food supply that is not being converted into the flesh of fish with sport or commercial value. The vacant niche theory holds that this food supply can be so converted without adversely affecting the rest of the ecosystem. Since niches are very complex, trying to predict the effects of a species introduction based solely on food supply on the resident biota is effectively impossible. This relegates the vacant niche theory to the realm of pseudoscience. Unfortunately, the vacant niche theory is usually the basis for the introduction of non-native game fishes, such as trout in small streams and centrarchids in ponds, lakes, and larger rivers.

Brook trout, brown trout, and rainbow trout, are stocked by the West Virginia Division of Natural Resources in Gauley River and numerous tributaries of New and Gauley Rivers to maintain a popular seasonal put-and-take fishery (West Virginia Department of Natural Resources 1998). Some streams are also stocked by local chapters of Trout Unlimited, but the source of these fish is usually the West Virginia Division of Natural Resources. With the possible exception of Gauley River, most of the stocked streams are warm water streams, and border on being unsuitable for long-term residence by trout.

It is believed that most stocked trout are caught within a short time after stocking, although many fish may live for many weeks or months after stocking. It is a common practice of local anglers to learn the stocking truck's route and await its arrival. This is especially true for Dunloup and Glade Creeks (NERI). The stocking location on Dunloup Creek is immediately downstream from the White Oak Public Service District Sewage Treatment Plant. This plant frequently bypasses sewage, with only chlorination for treatment, during storm events.

An apparently self-maintaining population of brook trout has become established in Buffalo Creek (NERI). The West Virginia Division of Natural Resources designates this stream as fly-fishing only. This regulation also entails a catch-and-release provision. An apparently self-maintaining population of brown trout has become established in lower Glade Creek (NERI). This stretch is designated a catch-and-release stream by the West Virginia Division of Natural Resources. With the lower three miles of Glade Creek managed on a catch-and-release basis, and the adjacent, upper three miles managed as a put-and-take fishery, an excellent opportunity exists to examine the impacts of these two fishery management techniques on stream ecosystems. This opportunity is addressed by the recommended action: **Determine Impacts of Two Fishery Management Methods on Stream Ecosystems**.

Brook trout are native to parts of the New and Gauley river systems, being taken in New River tributaries in Virginia in 1867 (Cope 1868). Addair (1944) collected brook trout throughout the highlands of the Gauley and Greenbrier River Basins, and also in Meadow Creek and an unidentified tributary of the New River in the Gorge area. Stocking of brook trout was reported by Addair, and began as early as 1876 in parts of Virginia (Jenkins and Burkhead 1994). Brook trout are not considered native to the streams near New River Gorge in historical times (D.A. Cincotta, West Virginia Division of Natural

Resources, personal communication 1998). This species is notoriously intolerant of warm water, but is otherwise a habitat generalist (Jenkins and Burkhead 1994). Although discussion of its distribution prior to recorded surveys is speculative, it seems plausible that it would have existed in the New River main stem and tributaries wherever climatic conditions allowed. Most of these areas would be upstream of New River Gorge National River, and at higher elevations than are found in the park.

Brown trout, native to Europe, Asia, and North Africa, were introduced to North America in 1883 (Jenkins and Burkhead 1994). Brown trout out-compete brook trout in the warmest streams where the latter could survive (maximum temperatures on the order of 15^{o} to 20^{o} C). Brook trout remain successful in colder waters at higher elevations, generally above 2000 ft in West Virginia (Stauffer *et al.* 1995).

Rainbow trout are native to Siberia and the Pacific Northwest of North America. Like brown trout, they have been introduced worldwide (Jenkins and Burkhead 1994). A considerable body of literature on interactions between brook trout and rainbow trout has been compiled at Great Smoky Mountains National Park (Etnier and Starnes 1993). Isolated reproducing populations of both brown and rainbow trout exist in West Virginia despite intense fishing pressure (Stauffer *et al.* 1995).

A study on predation of New River endemic candy darters (*Etheostoma osburni*) by stocked rainbow trout found that two weeks after stocking, no candy darter remains were present in rainbow trout guts (Leftwich *et al.* 1996). The authors were not convinced that trout predation on candy darters did not occur, however, and were particularly concerned about possible predation of candy darters by brown trout. Little else is known about interactions between trout and their prey in the streams of New River Gorge National River and Gauley River National Recreation Area. This concern is addressed in the recommended action: **Determine Diets of Exotic Trout in New River Gorge Tributaries**.

The effects of non-native predators on stream ecosystems is probably not limited to just their prey species. Because all species in a given ecosystem interact to some degree, effects on one species are likely to have ramifications to other species. For example, if stocked fish prey preferentially on a given species and reduces their population, then the prey of that species may increase. Of course these interactions are complex and can only be investigated by comparing streams with and without stocked fish. This concern is addressed in the recommended actions: **Evaluate Impacts of Exotic Trout on New River Gorge National River Tributary Ecosystems** and **Inventory Biological Resources of New River Tributaries.**

The primary game fish in the three parks, the smallmouth bass, is not native to the New or Gauley River basins (Cope 1868, Jenkins and Burkhead 1994). Although early stocking records are sketchy, smallmouth bass apparently were introduced to New River in the 1800's, and reproducing populations quickly were established. Other gamefish introduced into New River include muskellunge, walleye, and several sepcies of sunfish. Non-native gamefish introduced into Bluestone Lake, including striped and white bass and their hybrids, crappies, and shad are sometimes flushed into New River within New River Gorge National River. Similar but smaller populations of introduced gamefish exist in Gauley and Bluestone Rivers. Owing to the large size and habitat complexity of these rivers, the large number of introduced species, and the difficulty of sorting out the impacts of these many introductions, no recommended actions are presented that would address this issue.

Release of unwanted baitfishes has resulted in most establishments of non-native fish populations (Courtenay 1993). Several fishes that are expanding their range in the New River system are probably doing so because of "bait-bucket introductions." This concern is addressed by the recommended action: **Outreach to Anglers on the Effects of Bait-Bucket Fish Introductions**.

Besides fishes, crayfish and hellgrammites are commonly used baits in the area of the three parks. A commercial bait fishery exists in this area, especially in the New River between Bluestone Dam and Sandstone Falls (Nielson and Orth 1988, Roell and Orth 1992). Studies of crayfishes in the New River have shown dramatic changes in community composition (Roell and Orth 1992). This is mostly attributed to the introduction of non-native species by way of discarded bait (Miller 1997). No survey of New River crayfishes has been completed since 1984-85. Whether introduced crayfishes have continued to expand their dominance of the community, and the status of native crayfishes is of serious concern. This concern is addressed in the recommended action: **Determine Status and Trends of New River Crayfish Community**.

Bti Application to Remove Black Flies

Residents along and near the New River have long complained about the nuisance of black flies (*Simulium jenningsi*). Adult female black flies bite humans. While they are disease vectors in some tropical areas, in temperate North America, they are considered merely a nuisance (Merritt and Cummins 1996). Larval black flies live in swift flowing water, where they cling to stones and other fixed objects, and feed by filtering small particles out of the water.

In 1983 the West Virginia Division of Natural Resources began exploring the feasibility of eliminating populations of *S. jenningsi* by applying the bacterial insecticide *Bacillus thuriingiensis* var. *israelensis* (Bti). Spraying of Bti would occur by helicopter into New River and its major tributaries Bluestone River and Greenbrier River (Voshell and Orth 1995). Ingested *Bti* acts by excreting a toxin in the midgut of the aquatic black fly larvae that prevents transformation to the adult form (Voshell and Orth 1995).

In 1986 the West Virginia Division of Natural Resources applied *Bti* in the New River for evaluative purposes (National Park Service 1995b). The National Park Service opposed this activity within park boundaries on grounds that they had authority over wildlife within the park's boundaries, the program violated the agency's mission, there was not a documented health risk, and little was then known about effects of *Bti* on non-target organisms. The National Park Service obtained a court injunction prohibiting spraying of *Bti* within park boundaries. In 1987 the Federal Supplemental Appropriations Act authorized the State of West Virginia to apply *Bti* to New River within National Park Service boundaries for 8 years. This act mandated the National Park Service and the West Virginia Department of Natural Resources to jointly conduct an ecological monitoring program. Widespread *Bti* treatments began in 1988 (Voshell and Orth 1995). The spraying program was later taken over by the West Virginia Division of Environmental Protection, and is presently managed by the West Virginia Department of Agriculture. Typically, *Bti* is applied to New River roughly every 2 weeks from May through October, with a target exposure to river animals of 22 parts per million per minute.

In 1988 the NPS contracted Virginia Polytechnic Institute and State University to determine the effects of *Bti* application on the aquatic biota of New River, and to develop a long-term monitoring plan to track the aquatic biota so that future disturbances would be apparent (Voshell *et al.* 1990a). The LTEMS program was created to meet these needs (Voshell *et al.* 1990b). The main goal was to assess environmental impacts that might result from the black fly management program (National Park Service 1995b). A second goal was to design a system to determine impacts to the New River from other anthropogenic activities.

The system originally consisted of five sites on the main stem of New River (Voshell *et al.* 1990b). The most downstream site was eliminated in 1998 due to lack of suitable sampling habitat, and concern for the safety of park staff and visitors. Annually, at low flow (usually about the first two weeks of August) a variety of habitats are sampled from wadable parts of the stream sampling sites. Quantitative and qualitative samples are collected. Macroinvertebrates, macrophytes, and fish are collected, identified, quantified, and measured. Determining chlorophyll-a concentrations from samples approximates abundances of periphyton and phytoplankton. Determinations are made of dissolved oxygen, pH, alkalinity, hardness, specific conductance, suspended particulates and fecal coiform bacteria. Discharge is determined from two U. S. Geological Survey gages, New River at Hinton and New River at Thurmond.

Effects of *Bti* application on production of several fish species and dominant invertebrate taxa were assessed by an intensive three-year study (1988 to 1990) at 2 sites (downstream from Bluestone Dam, and Sandstone Falls) (Voshell and Orth 1995). Post-treatment invertebrate production was compared to pre-treatment invertebrate production measured in 1983 (Bluestone Dam), and 1987 (Sandstone Falls). Post-treatment production data were also available from 1986 for the Bluestone Dam site (Voshell 1985). Dominant invertebrate taxa varied among sites and years. Invertebrate samples were collected every two weeks from June through November, unless flow was high. Targeted habitat was riverweed mats on rock outcrops**.**

Macroinvertebrate community composition data collected at the same sites before treatment in 1982 and 1984, and after treatment in 1988 to 1990 were also examined for change caused by *Bti* application. Metrics were calculated from cobble-pebble riffle samples, which had previously been shown to be the habitat containing the most diverse invertebrate assemblage. Additional water quality measurements (major ions, aluminum, iron, manganese, zinc, and nutrients) were also determined.

The fish community was sampled at these two sites three times annually for the 3-year period (Voshell and Orth 1995). Pre-treatment data used for comparison were from a 1979 regional study of fish distribution (Stauffer *et al.* 1980) and a 1984 study of microhabitat use by various fish species (Lobb 1986). Neither of the pre-treatment fish studies sampled at the same sites as those used in the post-treatment studies. Also, both pre-treatment studies used different, more intensive methods than did the post-treatment studies.

The investigators acknowledge that the *Bti* study suffered from several limitations out of their control (Voshell and Orth 1995). Because the study began after *Bti* treatment had already begun, pre-treatment data sets were limited to 1 or 2 years, and year-to-year hydrologic variability could not be eliminated as a confounding factor. Pre-treatment data sets were often collected with substantially different methods, and all were collected for a different purpose. No suitable nearby reference site was available, so comparisons between environmentally similar, treated and untreated sites, under similar flow regimes, were impossible. No measurements were made of total within-site area of different habitat types, so that it is unknown whether targeted habitat samples were representative.

Voshell and Orth (1995) found that *Bti* application effectively removed black flies from New River, but failed to find any other effects on the invertebrate community. Further statistical analysis of this data set supported this conclusion (Smith and Marini 1998). Increased productivity of caddisflies, which may compete for food with black flies, was considered a possible side effect of *Bti* application. This study should have detected this effect, had it occurred. Another potential effect was that *Bti* would kill midges. Neither of these effects was detected. Instead, production levels were deemed to be high, and to indicate proper functioning of the New River ecosystem.

An effect on midges cannot be ruled out, because of taxonomic resolution. In LTEMS, all members of the family Chironomidae are grouped as single taxa. An effect on midges could quite possibly be genus- or species-specific. Identifying all midges to genus- or species-level, however, would be impractical if not impossible (Merritt and Cummins 1996). Sorting midges usually take enormous amounts of time, as densities of 50,000 per square meter may be encountered. Only a small percentage of midge larvae have been described, and taxonomic keys do not usually distinguish between larvae of different midge species. Larvae of several important groups of genera are considered essentially inseparable, even by acknowledged midge experts (Merritt and Cummins 1996).

A 5-year study on the effects of *Bti* application on non-target organisms in the Susquehanna River in Pennsylvania had findings consistent with the New River study (Jackson *et al.* 1994, Academy of Natural Sciences of Philadelphia 1990, 1991, 1996, 1997, 1998). The study was designed specifically to determine acute effects of single applications of *Bti*, rather than cumulative, long-term effects (Academy of Natural Sciences of Philadelphia 1998). *Bti* application effectively increased black fly drift from the treatment area, and black fly densities decreased markedly after treatment (Jackson *et al.* 1994). This study found no evidence of ecologically significant changes for non-target macroinvertebrates or fish that could be attributed to a single *Bti* application (Academy of Natural Sciences of Philadelphia 1998). No consistent effect of *Bti* on non-target organisms (the same effect seen on a given species in several years) was found, although some apparent effects were noted. The authors considered the magnitude of these effects “rather small,” and did not feel they could determine if these effects were the result of *Bti* application or of other factors unrelated to *Bti*. *Bti* was implicated in a post-treatment decrease in density of the aquatic moth *Petrophila* sp. in 1989 (Jackson *et al.* 1994). Post-treatment growth rates of YOY banded darters decreased in 1989, and their average condition decreased in 1990 (Academy of Natural Sciences of Philadelphia 1991). Fish growth and condition were measured each year of the study, and these effects were not replicated in subsequent experiments (Academy of Natural Sciences of Philadelphia 1998). Drift of different taxa of invertebrates increased significantly in some experiments, but except for *Petrophila*, was not replicated. Drift patterns of non-target organisms never exhibited the distinctive pattern of black fly drift.

In New River, some effects of *Bti* application on non-target organisms might be only long-term and may not manifest themselves for years. Another possibility is that invertebrate community changes may occur, but are too subtle to detect. Finding a possible highly subtle effect (which might not exist) would divert park staff from other pressing and more tractable problems. Smith and Marini (1998) point out that intensively monitoring a few sites is expensive in terms of staff time, and that evidence from other studies indicates that greater gains in information can be obtained by collecting information at more sites in a less intensive manner. Park managers should examine LTEMS and distinguish those parts of the study that measure general long-term trends from those that are specifically designed to determine effects of *Bti* application, and should seriously consider decreasing the resources devoted to monitor effects of *Bti* application. This is addressed by the recommended action **Evaluate the Long-Term Monitoring Program in New River Gorge National River**.

Since black flies feed by filtering particles from the water column, their removal from the ecosystem makes this food available to other filter feeders. Many of these organisms are insects, and are therefore sampled by the existing LTEMS protocols. One major group of filter feeders, however, is not sampled. These are the freshwater mussels. Whether native mussels in the New River might benefit from removal of blackflies, or might suffer from the well-established exotic Corbicula fluminea, is of some concern. The worldwide decline of mussel species makes this issue more urgent. This concern is addressed in the recommended action: **Determine Status and Trends of New River Mussel Community**.

Medium Priority Issues

<u>Silvicultural Activities</u>

West Virginia sits at the geographic center of the Appalachian Hardwood Belt (mixed mesophytic forest). Soil and climate provide an excellent growing environment for hardwoods. Currently there are 11.6 million acres of timberland in the state with 75 billion board feet of timber. Forestlands comprise 76 percent of the state's acreage. Sawtimber (commercially harvestable timber, diameter at 4.5 feet from ground of at least 11 inches for hardwoods) comprises 63.7 percent of the timber statewide. Poletimber (diameter at 4.5 feet from ground of 5-11 inches for hardwoods) accounts for 26.2 percent, and seedlings and saplings comprise the remaining 10.1 percent. Major timber reserves in millions of board feet of timber include (West Virginia Division of Forestry 1997) red oak (15.3), white oak (14.4), yellow poplar (12.7), red maple (3.7), hickory (3.2), sugar maple (3.0), black cherry (2.4), basswood (2.1), ash (1.8), and birch (1.0).

Statewide, timber volumes and timberland acres have increased steadily for more than 40 years, and are at the highest levels of the past century. The statewide ratio of timber growth to timber removal is 1.31 (West Virginia Division of Forestry 1997). This suggests that timber harvesting could continue for many years. However, a detailed study of forest industry sustainability in Virginia found that harvest was probably proceeding at an unsustainable rate (Virginia Department of Forestry 1999). Factors other than logging, including tree mortality but primarily urban sprawl, account for substantial forest loss in Virginia. No such study has been done in West Virginia.

Fayette, Mercer, Nicholas, Raleigh, and Summers counties have over 1.3 million acres of forest lands, with a ratio of timber growth to removal of 5.56. About 67 percent of this acreage is sawtimber (DiGiovanni 1990). There are 21 sawmills in these counties that each produces more than 100,000 board feet of lumber per year. There are also 4 drying kilns, 3 pressure treating plants, 1 rustic fencing mill, 2 veneer mills, 16 wood product manufacturers, and 1 engineered wood products plant.

The Development Authority of Mercer County is recruiting new forest industries for southern West Virginia. Top selling points include nearby quality stands of hardwood timber and a U.S. Forest Service laboratory and hardwood technology center near Princeton. These facilities provide assistance in hardwood research, utilization, and marketing. The potential exists for increased logging activity and associated timber processing industries near Bluestone National Scenic River and New River Gorge National River.

Unless carefully managed, timber harvest substantially alters the physical environment of streams. Changes in stream flow and increased sedimentation are among the most serious consequences of logging activities because they have long-term effects on channel and habitat features. By removing the overstory canopy, logging also exposes the streambed to increased solar radiation, resulting in warmer temperatures and greater autotrophic production.

There is ample evidence that poorly regulated forest harvest has resulted in substantial degradation in habitat and fish populations (Bisson *et al.* 1992). Simplification of channel structure and reduction in habitat complexity are common features in forests managed for timber harvest. As more of the basin is logged, the frequency and size of pools declines due to filling of pools with sediments and loss of pool-forming large woody debris. Complex channel margins that provide important edge habitat also become simplified in the absence of large flow obstructions such as logs and boulders. Catastrophic events including floods and landslides are more likely, especially where slopes are steep and unstable.

These changes in stream habitat result in numerous and often complex changes in the aquatic biota. In general one observes a reduction in fish species diversity (Bisson *et al.* 1992), attributed to habitat simplification, and an increase in standing crop biomass, attributed to greater light penetration and autotrophic production. Aquatic invertebrates are also adversely affected by clear-cut timber harvest (Bisson *et al.* 1992).

Riparian vegetation directly influences instream water quality through its moderating effect on temperature. Taxa adapted to cool waters are likely to be eliminated by temperature increases following canopy removal (Barton *et al.* 1985).

An increased amount of fine sediments within the streambed reduces its permeability to water movement, affecting the delivery and removal of gases, nutrients, and metabolites, and potentially restricting movements by animals.

Research at Coweeta Hydrologic Laboratory in the southern Appalachians of western North Carolina describe numerous effects of logging on water quality and the aquatic communities of small mountain streams. General effects include physical habitat alterations, changes in hydrologic, chemical, and thermal characteristics of the water, and changes in food resources (Webster and Swank 1985a). Specific effects include:

- increased stream temperature after cutting (Greene 1950), especially if trees and vegetation along stream channels are removed (Swift and Messer 1971);
- decreased retention and increased export of nutrients (Webster and Swank 1985b, Golladay *et al.* 1992);
- reduction in the number of woody-debris dams; and
- increased in streambed erosion; and increased sediment loads (Webster *et al.* 1988).

A stream's recovery rate after logging is dependent upon the recovery rate of terrestrial vegetation (Webster *et al.* 1992). Thus, streams in the southern Appalachians may continue to show signs of disturbance more than 100 years after major logging. Similar impacts may be expected in the region of Bluestone National Scenic River, New River Gorge National River, and Gauley River National Recreation Area.

Implementation of best management practices may significantly reduce the negative impacts of logging on stream ecosystems (e.g. Kochenderfer *et al.* 1997). For example, riparian buffer strips may provide adequate shade to reduce temperature increases. Buffer strips and alternatives to large area clearcutting may reduce increases in peak and storm flows after logging. Proper application of fertilizers during revegetation may reduce stream nutrient increases. Limiting the number of roads may significantly reduce stream sediment load increases.

Effluents from wood processing plants also can impact steam quality. A Georgia Pacific (GP) oriented strand board (OSB) plant came on-line in July 1995. Initially this plant discharged its process waters into the Mount Hope STP on Dunloup Creek. These process waters contained 29 constituents, of which nine (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, and phenols) are listed as toxic substances in section 307 of the Clean Water Act. At high flow when the Mount Hope STP was in a bypass mode (see **Sewage Pollution** issue), the GP plant was automatically notified, and process waters were not passed to the STP. In June 1996 the GP plant began recycling its process waters, and quit routing them to the STP. Since June 1996, the only releases to Dunloup Creek from the GP plant are storm water discharges through several outfalls into Sugar Creek, a tributary to Dunloup Creek. Georgia Pacific samples these discharges regularly according to West Virginia Division of Environmental Protection storm water monitoring requirements.

Agricultural and Urban Runoff

Agricultural and urban runoff are the primary sources of non-point pollution in the streams and rivers of the three parks. Agricultural runoff is a major source of pollutants to aquatic habitats. In the United States, some 80% of the 4.9 billion metric tons of soil eroded from non-federal rural land occurred on cropland (Allen 1995). Agricultural sources are responsible for 46% of the sediment, 47% of total phosphorus and 52% of total nitrogen discharged into waterways within the United States.

High rates of soil erosion and runoff of fertilizers, pesticides and herbicides are common problems of agriculturally impacted rivers, whereas municipal and industrial wastes are important pollutants of urbanized rivers. An increased load of silt and sediments is typical of rivers draining agricultural and urban landscapes.

Increased nutrient concentrations are serious and well-known consequence of a greater human presence in a watershed. Agriculture increases nutrient levels due to fertilizers and animal wastes, and also by increasing soil erosion which particularly affects the transport of phosphorus. Municipal wastes and fertilizers are significant nutrient sources from urban areas.

Collectively, the physical and chemical changes that result from agricultural and urban development change the ecology of rivers in many ways. In small streams, the energy base becomes less heterotrophic (i.e., reliance on outside sources of energy such as falling leaves from trees) and more autotrophic (i.e., reliance on in stream sources of energy) (Allen 1995). Habitat quality usually declines and biological communities become dominated by a smaller number of species that are more tolerant of these degraded conditions.

Agricultural census data for 1992 listed over 22,000 acres of farmland that were treated with commercial fertilizers in the five counties containing the three parks. These same counties had more than 3,500 acres sprayed with insecticides and more than 2,400 acres sprayed with herbicides. Greenbrier, Pocahontas, and Monroe counties that contain most of the Greenbrier River watershed (tributary to New River) had more than 52,000 acres of farmland treated with commercial fertilizer, more than 5,700 acres sprayed with insecticides, and more than 17,000 acres sprayed with herbicides.

Agricultural census data for 1992 listed more than 29,000 head of cattle for the five counties that contain the three parks, and 77,000 head of cattle for the counties that include most of the Greenbrier River watershed. The 1992 census did not indicate any large-scale poultry operations in the watersheds affecting the park units. The 1987 census indicated the existence of a large-scale poultry operation in Ashe County, North Carolina (headwaters of New River). This operation was converted to tree farms between 1987 and 1992 (Mark Kozar, U. S. Geological Survey, personal communication 1998).

British United Turkeys of America started a turkey breeding industry in Greenbrier County in the early 1990's that does not show up in the 1992 agricultural census. This poultry industry currently consists of approximately 20 poultry houses for breeder turkeys. No additional breeder facilities are planned for Greenbrier County. Poultry houses are cleaned out once every 30 weeks. Requests for poultry litter to apply to farmlands exceeds the amount of litter produced (Paula Brown, British United Turkeys of America, personal communication 1998). Any amounts of fecal material or nutrient loading to Greenbrier River would thus be relatively minimal, and would probably be well diluted before reaching the confluence with New River.

While the census data show population fluctuations, the general trend shows the larger population centers will continue to grow. No storm water retention measures are in place, and in most municipalities storm water and sewage are routed through the same systems (see **Sewage Pollution** issue). Additionally, as human activities alter the landscape, adverse impacts to tributary streams may result from changes in the quality and quantity of storm water runoff. The type and quality of pollutants carried by storm water runoff, commonly resulting in non-point source pollution of receiving waters, are highly variable. The pollutants carried by storm water runoff are largely based on land use characteristics and vary with duration and intensity of rainfall events (Table 10).

Table 10. Examples of pollutant characteristics (in kg/ha-yr) found in storm water runoff from various land uses in the Great Lakes region (after U.S. Environmental Protection Agency 1993).

Land Use	Suspended Sediment	Total Nitrogen	Total Phosphorous	Lead
General Agriculture	5-8000	0.8-75	0.1-9	0.003-0.09
Cropland	30-7500	6-60	0.3-7	0.006-0.007
Forested	2-900	1-8	0.03-0.7	0.01-0.05
General Urban	300-2500	8-10	0.5-4	0.02-0.6
Residential	900-4000	6-9	0.6-1	0.08
Commercial	75-1000	3-12	0.09-0.9	0.03-1.0
Industrial	750-2000	3-13	0.9-6	--
Developing Urban	>10,000	90	>10	3.0-7.0

Urban runoff quantity and quality are significantly affected by watershed development. Urbanization alters the natural vegetation and natural infiltration characteristics of the watershed, causing runoff from an urban area to have a much higher surface flow component, a much smaller ground water component, and a somewhat reduced baseflow component (U. S. Environmental Protection Agency 1993). Urbanization also can create water quality problems because activities associated with urbanization create sources of pollutants for surface runoff. Thus urbanization tends to increase runoff and pollutant loadings to receiving waterbodies. For example, Mott (1996) found that several heavy metals (mainly aluminum, iron, cadmium, and manganese) were found in excess of state standards by New River Gorge National River water quality monitoring. These exceedances occurred most frequently in the tributaries, but some exceedances of lesser magnitude occurred in the main stem (Wood 1990).

One significant effect of urbanization is to increase pollutant runoff loads over predevelopment levels (U. S. Environmental Protection Agency 1993). During a storm event, land surfaces, including impervious surfaces, are washed by rainfall, and the resulting runoff creates an increased loading of pollutants to receiving streams. Pollutant concentrations in urban runoff vary considerably, both during the course of a storm event and from event to event at a given site, from site to site within a given urban area, and from one urban area to another. This variability is a result of variations in rainfall characteristics, differing watershed features that affect runoff quality and quantity, and variability of urban activities. Table 11 presents ranges of urban runoff pollutant concentrations based on results of the Nationwide Urban Runoff Program (U. S. Environmental Protection Agency 1993). Potential sources of urban runoff pollutants are presented in Table 12. The principal types of pollutants found in urban runoff from these various sources include sediment, oxygen-demanding substances (organic matter), nutrients (e.g. phosphorous and nitrogen), heavy metals (e.g. copper, lead, zinc, etc.), pesticides, hydrocarbons (incl. PAHs, others), temperature, and trash/debris.

Table 11. Ranges in pollutant concentrations found in urban runoff. All constituents measured as mg/L except total copper, lead, and zinc which are measured in ug/L (after U. S. Environmental Protection Agency 1993).

Constituent	10th percentile	Median	90th percentile
Total Suspended Solids	35	125	390
BOD	6.5	12	20
COD	40	80	175
Total Phosphorous	0.18	0.41	0.93
Nitrate-Nitrogen	0.40	0.90	2.20
Total Copper	15	40	120
Total Lead	60	165	465
Total Zinc	80	210	540

The most important factor in determining the quantity of runoff that will result from a given storm event is the percent imperviousness of the land cover. Other factors include soil infiltration properties, topography, vegetative cover, and previous conditions.

The factors that influence the hydrologic characteristics of storm water are dependent on the phase of urbanization of an area. During the construction phase, the hydrology of a stream changes in response to initial site clearing and grading. Trees that had interrupted rainfall are felled. Natural depressions that temporarily ponded water are graded to a uniform slope. The thick humus layer of the forest floor that had absorbed rainfall is scraped off or eroded away. Having lost much of its natural storage capacity, the cleared and graded site can no longer prevent rainfall from being rapidly converted to runoff.

After construction is completed, rooftops, roads, parking lots, sidewalks, and driveways make much of the site impervious to rainfall. Unable to percolate into the soil, rainfall is converted to runoff. The excess runoff becomes too great for the existing drainage system to handle. As a result, the drainage network must be improved to direct and convey the runoff away from the site.

Table 12. Sources of urban runoff pollutants (after U. S. Environmental Protection Agency 1993).

Source	Pollutant of Concern
Erosion	Sediment and attached soil nutrients, organic matter, and other adsorbed pollutants
Atmospheric Deposition	Hydrocarbons emitted from automobiles, dust, aromatic hydrocarbons, metals, and other chemicals released from industrial and commercial activities
Construction Materials	Metals from flashing and shingles, gutters and downspouts, galvanized pipes and metal plating, paint, and wood preservatives
Manufactured Products	Heavy metals, halogenated aliphactics, phthalate esthers, PAHs, other volatiles, and pesticides and phenols from automobile use, pesticide use, industrial use, and other uses.
Plants and Animals	Plant debris and animal excrement
Non-storm water Construction	Inadvertent or deliberate discharges of sanitary sewage and industrial wastewater to storm drainage system
Accidental Spills	Pollutants of concern depend on the nature of the spill

Changes in stream hydrology in a typical, moderately developed watershed include (Schueler 1987):

increased peak discharges compared to predevelopment levels;
increased volume of storm runoff produced by each storm in comparison to predevelopment conditions;
decreased time needed for runoff to reach the stream;
increased frequency and severity of flooding;
reduced stream flow during prolonged periods of dry weather due to the reduced level of infiltration in the watershed; and
greater runoff velocity during storms, due to the combined effect of higher peak discharges, rapid time of concentration, and the smoother hydraulic surfaces that occur as a result of development.

Development is occurring throughout the New River watershed. In some cases it is occurring close to park boundaries, and in other cases many miles away. Owing to the complexity of this issue, no recommended action is presented to address it. However, continuation of the existing water quality and long-term biological monitoring programs are important to discerning impacts from development activities. Maintaining flexibility in the water quality monitoring program is essential to evaluating specific development activities occurring close to the parks.

Mineral Development

Active and abandoned coal mines and oil and gas wells are present in or near the three parks. These activities pose existing and potential environmental problems for park water resources.

Coal mining alters both surface water and ground water chemistry of small watersheds in southern West Virginia (Borchers *et al.* 1991). Streams draining mined areas had higher pH, specific conductance, and greater concentrations of calcium, magnesium, sodium, potassium, bicarbonate, sulfate, manganese, and dissolved solids than streams draining unmined areas. The higher pH was theorized to be a result of acid reduction treatment employed by the active mines. Other studies (Ehlke *et al.* 1982, Bader *et al.* 1989) have concurred that streams draining mined areas are typically alkaline in the low-sulfur coalfields of southern West Virginia. Borchers *et al.* (1991) also found that ground water from wells near underground mines had greater specific conductance and concentrations of sodium, calcium, bicarbonate, and sulfate than did ground water from wells more than 0.5 miles from underground mines.

A study of the hydrology of Area 9, Eastern Coal Province by Ehlke *et al.* (1982) found that concentrations of total iron and dissolved manganese were highest in streams draining areas that had been mined for several years. This study, which included New River Gorge and Gauley and Meadow Rivers, also found that pH of surface water in New River (median pH 7.3) was generally neutral to alkaline, and that pH of surface water in Gauley River (median pH 6.4) was more acidic. Reasons for this are the greater buffering capacity of New River (mean alkalinity 42 mg/L) versus that of Gauley River (average alkalinity 10 mg/L) and the higher sulfur content of the coals found in the Gauley River basin. The low buffering capacity of Gauley and Meadow Rivers make them more susceptible to acid drainage. A similar study of Area 10, Eastern Coal Province by Ehlke *et al.* (1983) found that pH in the Bluestone River basin that contained extensive mining of low-sulfur coal varied from 5.4 to 10.0. Median alkalinity for Bluestone River was 52 mg/L.

Although most waters in mined areas of this region are alkaline, there are some where acidity problems do exist. This occurs most often where high-sulfur coal (as opposed to the low-sulfur coal predominant in this area) was mined or processed. In these areas, mine drainages or seepage through piles of processing waste (‘gob’) may be acidic. These areas are generally small and isolated. The relatively high buffering capacity of streams in these areas generally neutralizes acid problems quickly, and limits impacts to a few feet even in the smallest streams.

One major exception occurs at the head of Wolf Creek, a New River tributary that enters New River Gorge National River a short distrance upstream of the downstream park boundary. A large volume of acid gob, imported to this site from outside the watershed, has caused serious problems. Wolf Creek flows through Oak Hill and Fayetteville, the two largest towns in Fayette County, and is a major portion of the water supply for Fayetteville. Prior to the onset of acidification problems, the State stocked trout in Wolf Creek. Water immediately downstream from the gob pile often exhibits a pH of less than 3, although pH usually reaches 7 or greater by the time the stream enters the park. Occasional acid drainage episodes, including one in 2002, result in acidic water entering the park. An earlier attempt to remedy this problem through reclamation of the gob pile failed. The NPS has been partnering with a consortium of federal, state, and local agencies and a local watershed group to address this problem. The recent settlement of a legal proceeding makes $375,000 available to treat the gob pile in a more effective manner. Monitoring of Wolf Creek above and within the park is needed to evaluate the effectiveness of this additional work. The recommended action: **Monitor Effectiveness of Wolf Creek AMD Treatment** addresses the within-park portion of this work.

According to a 1995 minerals summary of the parks, there are 115 abandoned coal mine sites within New River Gorge National River, 11 abandoned coal mine sites in Gauley River National Recreation Area, and no abandoned mines in Bluestone National Scenic River (Ken Stephens, New River Gorge National River, personal communication 1998). Abandoned mine lands were inventoried in the park units in 1991 and 1992. Gauley River National Recreation Area has the only active permit for a deep mine operation within park boundaries. Abandoned deep mines in this park are mostly punch mines that tend to be newer, smaller, and have fewer associated structures and refuse areas than the large deep mine complexes in the New River Gorge area. Strip mining has been occurring mainly since 1976 in areas adjacent to Gauley River National Recreation Area. Because the National Park Service owns only a small portion of the mineral rights to the parks, the Office of Surface Mining is responsible for determining if mining can be continued or reopened in the parks.

Coal mines have the potential to affect water quality of tributaries to the parks, especially New River Gorge National River (Table 13). Borchers *et al.* (1991) showed that mine drainages and discharges augment streamflow during dry periods and comprise a large percentage of the total streamflow. Thus an inventory of active and abandoned mines in all watersheds tributary to the parks, especially New River Gorge National River, would be useful to park management. Databases covering active mine permits, abandoned mine sites, and permitted mines discharges are maintained by the West Virginia Division of Environmental Protection.

Mountaintop removal mining activity, which involves the removal of complete seams of coal and all overburden and the disposal of this material into adjacent valleys, has occurred and is projected to occur in an area from Mingo County northeast to Webster County (Figure 5) (Fedorko and Blake 1998). This projected area covers most of the northern half of Nicholas County and would be visible to, and include parts of, the Gauley River National Recreation Area. The Peters Creek drainage would be among areas potentially impacted. Little is known about the impacts of valley fills from mountaintop removal upon tributary watersheds (Ronald Evaldi, U. S. Geological

Table 13. A summary of common sources and impacts of stream pollution associated with coal mining (after National Park Service 1987).

Pollution Source	Characteristics and Impacts
Mine shafts	Seeps from improperly sealed mine shafts may have an orange to yellow color, low pH (<3.0), high conductivity, and high concentrations of substances such as sulfate, iron, aluminum, manganese, and chloride.
Strip mines	Erosion from barren strip-mined areas will increase turbidity downstream following precipitation. Seepage from the spoil areas may have the same characteristics as mine shaft seepage.
Ponds	Runoff water from strip-mined areas that accumulates in ponds is typically coffee-colored and acidic, and it contains the high metal concentrations typical of acid mine drainage.
Roads	Both new and abandoned roads can erode, causing landslides and high turbidity and/or high sediment loads in streams.
Flooding and High Flows	Polluted streams that are choked with fallen vegetation and sediment will flood during periods of high stream flow and kill more vegetation. Also, mining activity can increase peak flows by a factor of three to five in small watersheds.

Survey, personal communication 1998). Mountaintop removal impacts from mines in the projected area would probably be minimal on New River Gorge National River and of no consequence to Bluestone National Scenic River due to the distance of these park units from the projected area of mountaintop mining. However, mountaintop removal mines exist outside of the projected area that may affect the parks.

Stream sediments in areas with a history of coal mining may exhibit high concentrations of polycyclic aromatic hydrocarbons (PAH). Analysis of three coal samples from the New River area showed them to contain between 20 and 85 percent PAH's by weight. In this area PAH's are present in sand- and finer-sized particles, and may present a significant threat to aquatic life. They have been shown to cause many lethal and sublethal adverse effects on a variety of aquatic organisms (Eisler 2000), including liver tumors in bottom feeding fish (Baumann *et al.* 1991). Unpublished USGS statistical analysis correlated PAH's with external fish anomalies in the New-Kanawha River watershed. Concentrations of many PAH's in streams draining mined areas in or near the park exceeded Environment Canada's Probable Effects Level for the protection of aquatic life. More information is needed on PAH's in park streams to determine how severe a threat they represent to aquatic life. This concern is addressed by the recommended action: **Determine Partitioning of Polycyclic Aromatic Hydrocarbons in Streams of the New River Watershed**.

A report (Sullivan 1992b) on oil and gas development in and near the three park units determined that there are 16 active, two shut-in, and five plugged and abandoned gas wells within Gauley River National Recreation Area. Another 61 gas wells are located within ½ mile of the park boundary. Because pressure in the gas reservoir in this area had dropped from 650 pounds per square inch (psi) to 2 to 5 psi by 1991, future production was forecasted to come from deeper units to the west of the park. However, there was speculation that the mature shallower fields of the park could be used for natural gas storage. There is also an extensive pipeline gathering and compression system connecting the wells to a major intrastate line. In New River Gorge National River there is one active, one shut-in, and four plugged wells. The park has acquired surface ownership for all of these except the active well. Bluestone National Scenic River has no gas wells within its boundaries, although a major oil and gas pipeline crosses the park. No oil wells are present in the any of the parks. Gas development activity has increased markedly since 1992, and a revision of the earlier report is underway.

Facilities associated with oil and gas development include producing, shut-in, plugged, and saltwater injection wells; petroleum, gas, and saltwater pipelines; active reserve and buried reserve pits; and storage tanks, as well as an extensive network of roads. There is a high potential for oil or chemical contamination of park waterways and aquifers from this development.

Potential, general effects of oil and gas activities on water resources are summarized in Table 14. Effects on water quality may be significant. Impacts to surface water quality are more likely to be short term and difficult to track, whereas impacts to ground water should be considered as long-term impacts. The retention time of pollutants in surface water may be months. The retention time for pollutants in ground water is commonly measured in decades or centuries. For this reason, pollution of ground water can be considered a significant, irreversible and irretrievable loss. The contamination of aquifers could also result in eventual contamination of surface waters that are in hydraulic contact with the aquifers. The magnitude of water contamination depends upon the volume of fluids lost, the local geography, and the composition of the fluids.

Specifically, during drilling and pumping activities, the potential exists for spills and leaks of drilling fluids, muds, oil, or produced wastes. Drilling fluids and natural ground water encountered in the drilling process are often high in dissolved salt content (especially sodium, calcium, magnesium, and chloride) and sometimes contain heavy metals such as barium, cadmium, chromium, lead, strontium, and zinc (National Park Service 1987a). Bicarbonates, carbonates, sulfates, sulfides, and oil may also be associated with produced waters and drilling fluids. The potential also exists for spills or leaks of such substances as detergents, fuels, machinery fluids, and toxic chemicals. Trucks transporting oil or produced water pose further spill hazards, and storage tanks or pumping stations sometimes rupture. Herbicides sprayed for brush control along pipelines and other cleared areas can enter streams by way of storm runoff. Finally, fallout of airborne particles (such as dust) can contribute to water pollution problems.

The largest volume of waste associated with oil and gas activities is produced water (brine). Most is saline. Total dissolved solids in produced water ranges from several hundreds parts per million (ppm) to over 150,000 ppm. Seawater, by comparison, is typically about 35,000 ppm. These high dissolved solid concentrations greatly impact freshwater resources. One barrel of brine can contaminate up to 1,000 barrels of freshwater (National Park Service 1987). Brine usually contains a small percentage of oil (0.10 to 0.33 percent by volume), dissolved gases such as hydrogen sulfide, and possibly trace elements which can also impact water quality. The actual composition of brine varies widely and needs to be determined to ascertain the potential impact of a spill. The oil and gas development inventory for the three parks (National Park Service 1991) noticed evidence of brine discharged directly to the ground during well cleaning.

Table 14. Potential effects of oil and gas activities on water resources. Modified from U. S. Forest Service and Bureau of Land Management (1991).

Activity	Potential Effects
Exploration road and drill pad construction	Increased runoff, erosion, and sediment to streams and impoundments. Impacts to aquatic flora and fauna.
Drilling reserve pit operations	Releases of produced brine, drilling mud and additives, and low hydrocarbons to surface and/or shallow ground water. Potential mortality of aquatic flora and fauna.
Blow outs	Releases of brine, drilling fluids, and hydrocarbons to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.
Production salt water disposal	Leakage from collector lines to surface or shallow ground water. Leakage from injection wells to potable water aquifers. Spills would kill vegetation and sterilize soil. Potential for mortality of aquatic flora and fauna.
Abandonment well plugging	Migration of brines through incompetent seals to potable aquifers.
Seepage and/or rupture of pipelines/storage tanks	Release of product to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.
Accidents from tanker truck spills	Release of product to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.

Oil and gas development has the potential to directly effect the aquatic flora and fauna by causing mortality. The most likely direct effect linked with mortalities would be associated with chemical spills and leaks whereby chemical contaminants find their way into watercourses. There is sufficient field and laboratory evidence that demonstrates both acute and lethal toxicity and long-term sublethal toxicity of oils and petroleum distillates to aquatic organisms (U. S. Environmental Protection Agency 1986). Depending upon the type of petroleum compound and the flora and fauna involved, lethal toxicities can be highly variable. Crude oil in concentrations as weak as 0.4 mg/l can be extremely toxic to fish. Also certain petroleum products that appear to have no soluble poisonous substances become deadly when emulsified by agitation, as would be the case in the often turbulent stream flows in three park units. Oily substances can harm aquatic life by: 1) adhering to gills and interfering with respiration; 2) coating and destroying algae and other plankton; 3) coating stream bottoms and destroying benthic organisms; and 4) direct lethal toxic action.

Direct monitoring of mineral development activities is outside the scope of the park water resources staff. Presently this monitoring is accomplished by a terrestrial biologist, but the need to hire a dedicated mineral specialist has been identified by park management. Communication among park staff, producers, and responsible agencies is essential to dealing with the potential threats from mineral activities. Maintaining the existing water quality monitoring program, and remaining flexible enough to deal with emergencies, are the most effective ways to deal with this potential threat. For these reasons, no specific recommended action is presented.

Future Development

The development plans listed below are typically flexible and change rapidly and thus represent only a snapshot of recent conditions. National Park Service officials must stay abreast of these development topics, for local entrepreneurs and government officials are aggressively promoting economic development in many areas near the parks.

The present highway system in southern West Virginia, which includes Interstates 64 and 77 and the divided four-lane U.S. Route 19, provides easy access to the three park units and surrounding communities for millions of potential visitors. According to the web page of the 4-C (County) Economic Development Authority, which promotes the economic development of Fayette, Nicholas, Raleigh, and Summers Counties, more than 17 million people live within a 200-mile radius and more than 57 million live within a 300-mile radius of this area.

Considerable economic development is in progress or in the planning stages along or in close proximity to Route 19 (Judy Radford, 4-C Economic Development Authority, personal communication 1998). One proposed development is the Sun Mountain Resort between Mount Hope and Oak Hill. Plans for this 800-acre tract feature a 360-room hotel, a conference and music center to seat 20,000, a housing development, and a professional golf course. Some ground clearing has occurred at this site, but financial backing appears to be inadequate, and no new work has occurred for about two years. A new industrial park within the city of Mount Hope has recently opened, and is recruiting occupants to fill its capacity. The West Virginia National Guard is proposing a 35-acre facility for the Glen Jean area. At one time financial backing was being sought to help fund an 11,000 to 12,000 acre wildlife park near Glen Jean. This proposal has not moved forward in the last couple of years. Additional ground clearing for proposed commercial development has occurred in the Bradley area between Beckley and Mount Hope. Like the Sun Mountain project, this surface disturbance occurs in the Dunloup Creek watershed. Both projects have aroused the concern of members of the Dunloup Creek Watershed Association.

Present developments in Mercer County, which has its own economic development authority, include Turnpike Industrial Park in Princeton and Cumberland Industrial Park near Bluefield. The county is recruiting primary processors and secondary manufacturers of wood products. A U.S. Forest Services Laboratory and hardwood technology center near Princeton provide assistance in hardwood research, utilization, and marketing (Development Authority of Mercer County, written communication 1998). Several new motels are being planned and constructed along I-77 in Mercer County (Janet Bailey, Director, Development Authority of Mercer County, personal communication 1998).

New River Gorge National River could be impacted both directly and indirectly by the construction of a proposed two-lane scenic parkway (New River Parkway), complete with recreational facilities, along the New River. The West Virginia Department of Transportation, Division of Highways is proposing the construction of a 10-mile stretch of scenic highway from I-64 to Hinton, West Virginia. The proposed route of the New River Parkway will cross the New River once at Sandstone and will proceed south along the westside of the river mainly following the routes of existing roadways. Construction of the New River Parkway was projected to begin in late 2000 (Norse Angus, West Virginia Division of Highways, personal communication 1999). Local opposition to some aspects of the plan has delayed its implementation.

The New River Parkway may increase area development and impact the local environment. Construction will provide quick access to the New River Gorge National River from I-64, and may attract more visitors. The Federal Highway Administration and West Virginia Department of Transportation (1998) projects traffic increases to be over 700 percent by the year 2014, as opposed to an increase of only about 30 to 40 percent for the no-build alternative. The New River Parkway will increase sediment loading during construction and storm runoff during and after construction. In addition to water resources, it will impact scenic views, flora, and fauna to different degrees (U.S. Department of Transportation *et al*. 1998).

The West Virginia American Water Company recently constructed a regional water system in central Fayette County that provides water to 6,000 customers. Customers include families on existing water treatment systems and families not currently supplied with public drinking water. The treatment plant is located on the New River near Beckwith, a short distance downstream from the downstream park boundary. This regional water system will increase the number of households on public water supplies, will take eight existing water plants offline, but will not provide any sewage treatment facilities (Fayette County Water Resources Plan 1997, Allen Parsley, West Virginia American Water Company, personal communication 1999). Sewage treatment, where existing for customers of the new water system, will be handled by existing sewage treatment plants. Fayette County and the community of Ansted are considering improvements to sewage treatment for future customers of the regional water system (Allen Parsley, West Virginia American Water Company, personal communication 1999).

Low Priority Issues

Impoundments

New River Gorge National is affected by operation of Bluestone and Claytor dams. Bluestone National Scenic River is affected by operation of Bluestone Dam. Gauley River National Recreation Area is affected by operation of Summersville Dam. General effects of these dams are changes in flow characteristics, water quality, and riparian and aquatic habitats. Geomorphic channel alterations may also be taking place, but studies addressing this question were not found. Other dam-related issues include changes in operational regimes at Bluestone Dam (dam safety, drift and debris, hydropower) and

Summersville Dam (hydropower). Construction of a proposed dam on Greenbrier River also would affect water resources in New River Gorge National River.

Bluestone Dam is operated for flood control and recreation (Gary Mankin, U.S. Army Corp of Engineers, personal communication 1998). The general operation scenario attempts to maintain a steady recreational pool within Bluestone Lake, except when additional waters are retained to minimize flooding. Also, discharge from Greenbrier River is monitored to assist in scheduling peak releases of retained storm water from Bluestone Dam. Daily adjustments of discharge are required to maintain a constant pool elevation because of hydropower regulation at Claytor Dam located upstream. The daily adjustments are advantageous to the rafting industry because they generally dampen short-period increased discharges into longer-period steadier discharges. This allows rafting groups to remain apart on the river.

Figure 20 illustrates conditions before and after flood-control regulation. Annual peak discharges before regulation (1949) were generally greater than annual peaks since regulation, and extremely large peaks have been attenuated.

Summersville Dam is operated for flood control, recreation, and water-quality augmentation (Gary Mankin, U.S. Army Corp of Engineers, personal communication 1998). The general operation scenario attempts to maintain a steady recreational pool during summer months. Exceptions occur when waters are retained to minimize flooding, or are released to augment water quality (increase dissolved oxygen and decrease water temperature) in Kanawha River (Steelhammer 1995). The scenario reduces the pool level during fall to increase flood-retention potential through winter and spring. This fall drawdown is conducted to be advantageous to the rafting industry when water-quality augmentation responsibilities have not depleted storage.

Effects from flood-control regulation are shown at the USGS gauging station Gauley River above Belva (Figure 21). Similar to New River, annual peak discharges on Gauley River prior to regulation (1965) were greater than annual peaks since that time, and extremely large peaks have been attenuated.

Reduction in water temperature and potential to elevate dissolved oxygen downstream from the dams are the primary water quality issues for Bluestone and Summersville Dams. These dams are bottom-release facilities that decrease stream temperature in the tailwaters. Summersville Dam is the larger impoundment, and cooler waters from its depths allow trout fishing to exist in the tailwaters within Gauley River National Recreation Area.

Recent construction of a 100-megawatt power generation facility at Summersville Dam will take advantage of existing lake elevations and release patterns. A license issued by the Federal Energy Regulatory Commission includes requirements for a raptor protection plan for power lines, flow and water quality (dissolved oxygen and temperature) monitoring plans, erosion control plan, and a plan to construct a commercial raft

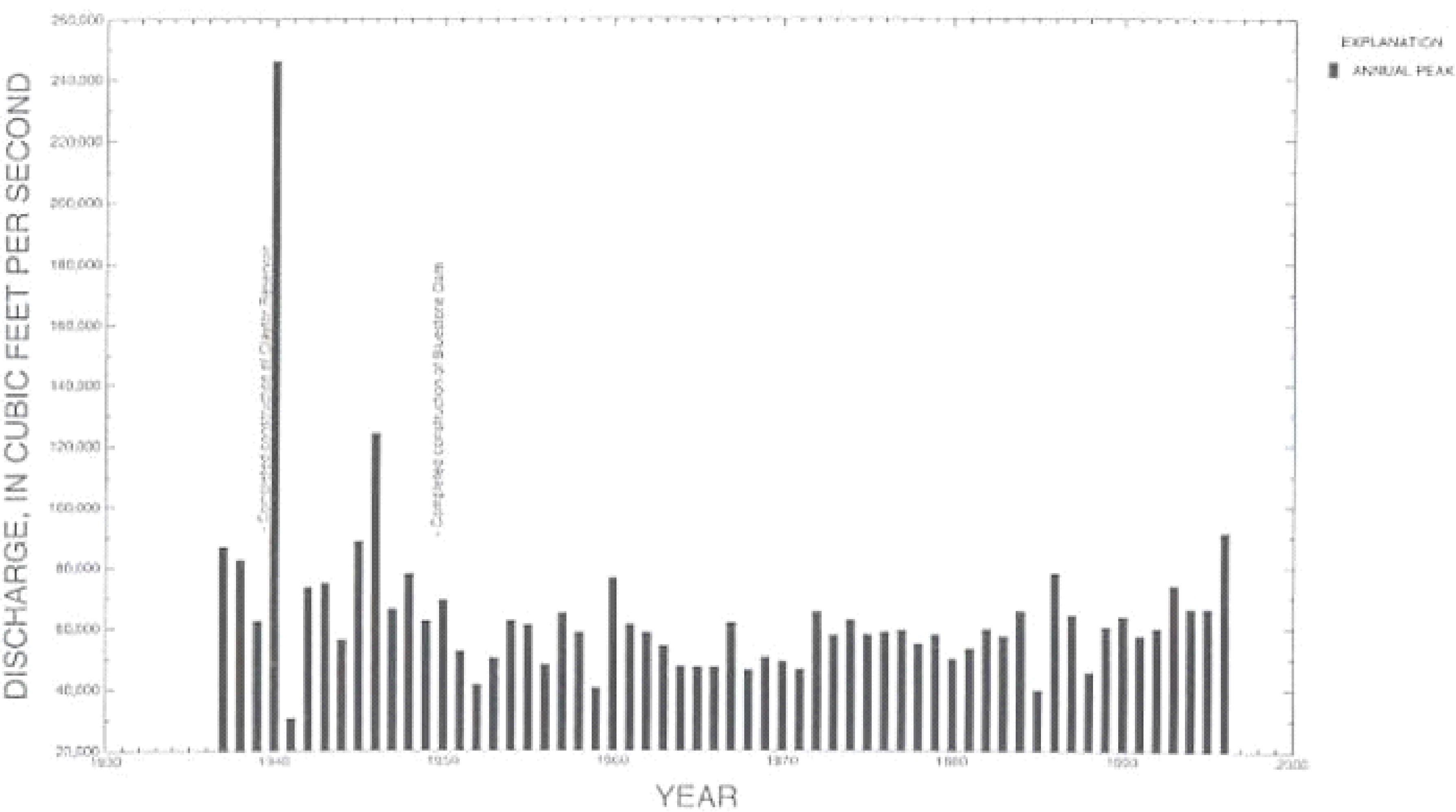


Figure 20. Annual peak discharges for the New River at Hinton.
After < http://www.usgs.gov >.

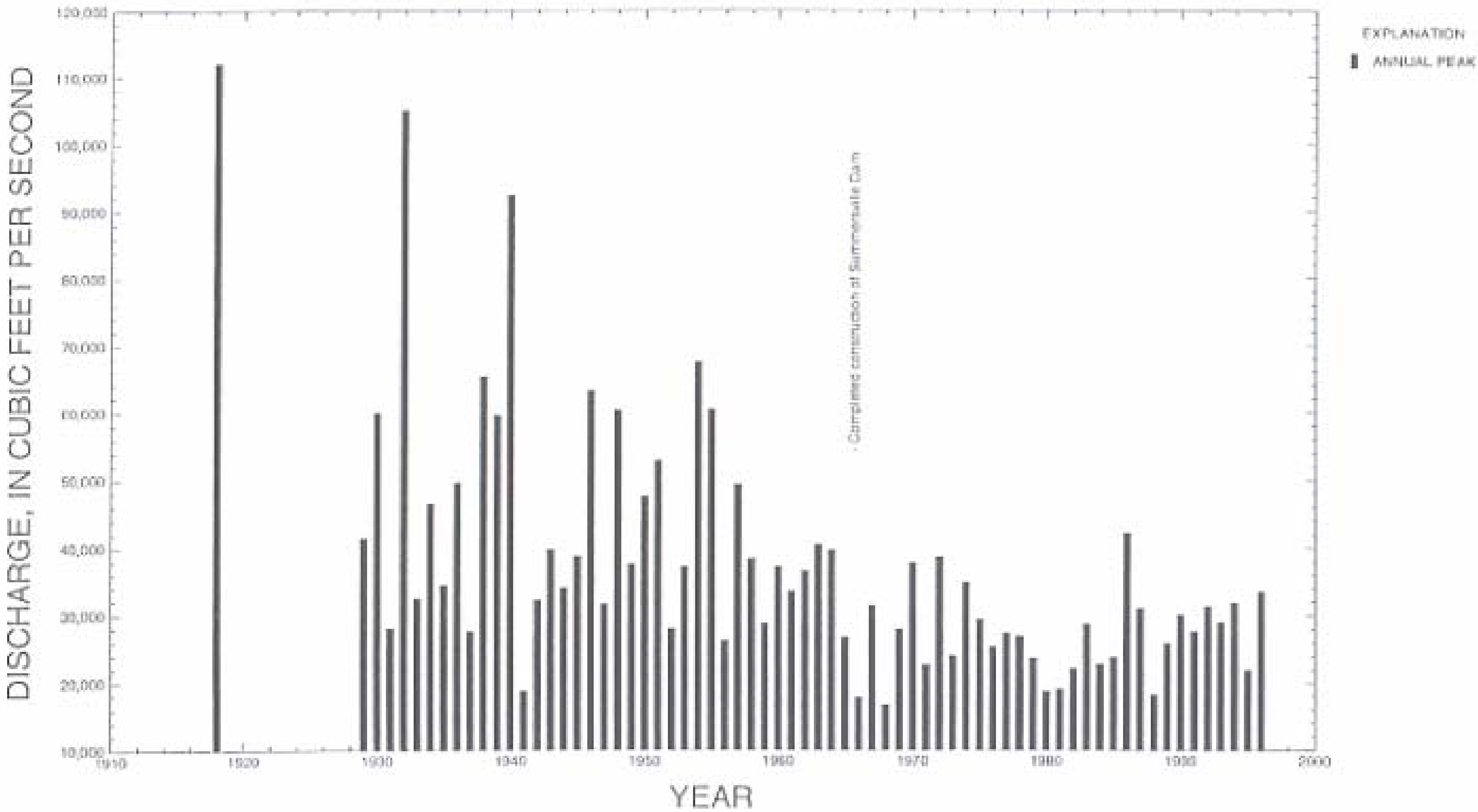


Figure 21. Annual peak discharges for the Gauley River above Belva.
After < http://www.usgs.gov >.

launching facility (Ken Stephens, New River Gorge National River, personal communication 1998).

The licensee will generate hydropower only from those flows established by the West Virginia National Interest River Conservation Act of 1988, the act that established the annual drawdown schedule that is favorable to whitewater rafting.

Ongoing renovation at Bluestone Dam will allow management of the maximum probable flood. Original design criteria for the Bluestone Dam were based on the maximum known flood (1878). Renovation includes raising the height of the dam by 13 feet, and anchoring the gravity dam to the bedrock. This renovation would not change the lake elevation or the regulation scenario described previously, although at extremely high inflow levels Bluestone Lake would encroach farther into Bluestone National Scenic River.

The passage of drift (wood, other natural materials) and debris (trash, other man-made materials) through Bluestone Dam into New River Gorge National River is an ongoing issue. The dam was originally designed as a hydropower and flood control structure, but was subsequently changed to a flood control-only structure. The design pool elevation was reduced 80 feet to increase flood storage, thus causing the trash chute to become unusable. In the past, Corps of Engineers policy was to pass all debris and drift through the dam in an episodic event following upstream flooding (U.S. Army Corps of Engineers 1985b). In cooperation with the National Park Service and the rafting industry, the Corps of Engineers experimented with ways to separate the debris from the drift, passing the drift through the low-level sluice gates while disposing of the debris in a landfill. These experiments led to the current plan of constructing a multi-level intake tower upstream of the dam face and a tunnel through the dam (Jim Twohig, U.S. Army Corp of Engineers, personal communiation 1998). This structure will allow drift to flow downstream concurrently with the event rather than being stored in Bluestone Lake and passed downstream at a later time. If the drift-and-debris chute changes the dam from a bottom release to a top release structure (this is a possibility, although construction details were not reviewed), then major changes in stream temperature, chemistry, and ecology could occur in New River within New River Gorge National River. The magnitude of these changes is unknown.

Proposed power generation at Bluestone Dam would raise the elevation of Bluestone Lake by a minimum of 11 feet (U.S. Army Corps of Engineers 1984). This would flood approximately 250 acres of Bluestone National Scenic River. The Water Rights Branch of the National Park Service's Water Resources Division has concluded that a water rights conflict between the reservoir project and New River Gorge National River does not exist. The legislation creating New River Gorge National River recognizes the purposes of both the park and Bluestone Dam, and stated that the Corps of Engineers should coordinate and cooperate with the National Park Service in scheduling releases from Bluestone Dam. The Water Rights Branch also concluded that no water rights conflict exists between the project and Bluestone National Scenic River. Enabling legislation for this park recognized the reservoir project and provided that nothing in the legislation creating the park shall affect or impair purposes of flood control, recreation, fish and wildlife, and hydropower (National Park Service 1995c). However, there remains a legal question surrounding the potential conflict between the requirement for a "free-flowing" river under the Wild and Scenic Rivers Act (National Park Service 1994b) and the effects that would result from a change in lake elevation. If the hydropower proposal becomes reality, the National Park Service should request that the Office of the Solicitor address this question.

Construction of a flood-control dam on Greenbrier River would further regulate streamflow in New River Gorge National River. This project has been proposed in the form of a wet dam on the main stem, one or more dry dams, and headwater dams on tributary streams (Lisa Metheney, U.S. Army Corp of Engineers, personal communication 1998). According to U.S. Senator Robert C. Byrd in a press release dated Monday, June 1, 1998, authorization of a dam on the main stem of the Greenbrier River is "virtually nil."

Regulation of flows in rivers brings about fundamental change in their structure and function (Vannote *et al.* 1980). Unaltered river ecosystems form a continuous strand from headwaters to mouth, in which processes taking place upstream strongly influence downstream dynamics, and to some extent the reverse occurs as well. A substantial fraction of the energy base of streams, especially smaller headwaters, is allochthonous through both surface and subsurface pathways. Flow regulation disrupts the natural conditions, both longitudinal and lateral, that strongly influence river ecosystems.

Flow regulation induces major discontinuities to resource gradients and zonation patterns along the longitudinal dimension (Ward and Stanford 1995). Biodiversity patterns along regulated rivers are characterized by major declines at riverine sites immediately downstream from dams, followed by relatively rapid increases concomitant with the recovery of environmental conditions. Stream regulation alters virtually all environmental variables downstream.

The sublethal effects of modified flow and temperature regimes are paramount in structuring biotic communities below many dams throughout the world (Petts 1984). For example, as a consequence of water's physical/chemical properties, the seasonal pattern is for downstream river water to be warmer than normal during the winter, cooler during summer, and of reduced seasonal amplitude overall. Total annual degree-days may be quite similar to an unregulated river, but the seasonal pattern of degree-day accumulation can change substantially. This can have consequences in species' life histories.

Secondly, regulation tends to isolate the river from its floodplain. Floodplains are created and maintained by the flood events that river regulation prevents. Therefore regulation prevents regeneration of floodplain sediments and water bodies, and doesn't allow the re-setting of succession of riparian and other floodplain vegetation. Isolation of the flood plain from a river does not allow formation of new floodplain, and accelerates the trend toward terrestrial conditions in existing floodplain habitats.

The impacts of flow alteration on river biota and their communities have been well-documented (Cushman 1985, Ward and Stanford 1995, Petts 1984, Calow and Petts 1992). However, a better understanding of cause and effect relationships, and of best management alternatives to minimize negative impacts, is needed (Allen 1995). Within regulated rivers, it is the consensus of the scientific community that the lack of hydrological variation (e.g. flow, sediment load, and water temperature) alters channel morphology, habitat suitability, and primary production. These alterations reduce habitat diversity and patchiness, prime factors in reductions in species diversity (Poff and Ward 1989, Sparks 1995, Stanford *et al.* 1996). The perpetuation of native aquatic biodiversity and ecosystem integrity depends on maintaining or restoring some semblance of natural flow variability (Richter *et al.* 1996).

In an unaltered northeastern river, Bain *et al.* (1988) noticed that an abundant and diverse assemblage of small fish species and size classes were restricted to microhabitats characterized as relatively shallow in depth, slow in current velocity, and concentrated along stream margins in riffles and pools. These shoreline habitats harbored over 90 percent of all fish and most of the species in the river. They developed a fish community-habitat model that reflected the simple pattern between the fish community in an unaltered river and the available instream habitat. This model conflicted with the traditional view of streams as a linear (vertical) sequence of riffle and pool habitats by emphasizing a shoreline-midstream orientation (horizontal).

The model was then applied to a highly regulated northeast river (Bain and Travnichek 1996). The normally abundant and diverse shoreline fish assemblage was reduced in river reaches with highly regulated flows and absent at sites with the greatest flow fluctuations. Fish species and size classes that used either a broad range of habitat, or a microhabitat that was concentrated in midstream areas were found in elevated densities as a group and peaked in abundance at the most flow regulated sites. These findings suggested that frequent and high flow variability imposed functional habitat homogeneity. The reduction and elimination of the shoreline fishes under fluctuating habitat conditions indicated that this assemblage was not able to effectively persist in its particular microhabitat even though it physically existed at all stream discharges. Without the functional availability of shallow, slow, shoreline habitats the river environment became one general type of usable habitat that was dominated by a few habitat generalists and those species specializing on channel habitats.

Bain and Boltz (1989) extended the results of Bain *et al.* (1988) to develop a hypothesis of how regulated flow would change fish communities in large rivers. Their 'regulated flow impact hypothesis' states that fluctuating flows change the densities and species composition of fish differently in shoreline and midstream habitats, and the extent of the change depends on the severity of flow regime alteration and distance downstream from dams. Based on this hypothesis, several predictions were postulated. These include: fluctuating river flows reduce the diversity and abundance of fish in shoreline habitats; fluctuating river flows have little affect on the abundance of midstream fish; species composition of midstream fish is dominated by habitat generalists; and species composition and abundance show a gradient as the effects of flow regulation diminish downstream.

Bain and Boltz (1989) tested these predictions in the regulated Tallapoosa River of the Southeast. These predictions, and others, were confirmed. It appears that the most sensitive measure of regulated flow effects is the response of the fluvial specialist component of fish assemblages in shoreline habitats. This fish habitat unit has been repeatedly found to be the most sensitive to flow alterations (Bain and Boltz 1989).

Riparian Area Management

Physically, riparian areas control mass movements of materials and channel morphology (Naiman and Decamps 1997). Material supplied to streams comes from erosion of stream banks, a process influenced by root strength and resilience, as well as from the uplands. Stream banks largely devoid of riparian vegetation are often highly unstable and subject to mass wasting that can widen channels by several to tens of feet annually. Major bank erosion is 30 times more prevalent on non-vegetated banks exposed to currents as on vegetated banks (Beeson and Doyle 1995).

In addition riparian areas provide woody debris. Woody debris piles dissipate energy, trap moving materials, and create habitat (Naiman and Decamps 1997). Depending upon size, position in the channel, and geometry, woody debris can resist and redirect water currents, causing a mosaic of erosional and depositional patches and habitats in riparian areas of streams (Montgomery *et al.* 1995).

Riparian forests exert strong controls on the microclimate of streams, especially small ones (Naiman and Decamps 1997). Stream water temperatures are highly correlated with riparian soil temperatures, and strong microclimatic gradients appear in air, soil, and surface temperatures, and in relative humidity.

Ecologically, riparian areas: provide sources of nourishment (allochthonous inputs to rivers and herbivory); control nonpoint sources of pollution (in particular sediment and nutrients, in agricultural watersheds); and create, through variations in flood duration and frequency and concomitant changes in water table depth and plant succession, a complex of shifting habitats at different spatio-temporal scales (Naiman and Decamps 1997).

The habitats of riparian zones have evolved in a cycle of flood and drought, but it is a system in which there is a natural repeating cycle of events. Riparian vegetation (for that matter, all floodplain vegetation), therefore, is adapted to natural flood regimes. Those species found on floodplains are there because they are better adapted to the conditions than nearby upland species. Five factors are critical in determining an individual plant's response to changes in water level: 1) the time of year during which flooding occurs; 2) flood duration; 3) water depth at time of flooding; 4) amount of siltation resulting from flood waters; and, 5) flood frequency (Buhlmann *et al.* 1987).

A delicate balance exists between the flora and fauna of riparian habitats and the annual flood regime. Unusually high summer flows may scour beds of aquatic vegetation reducing cover for young of the year fish, turtles, and invertebrates. Summer destruction of these plant beds may affect waterfowl food supply and survival the following winter. Ill-timed artificial flows may destroy larvae of amphibians by flushing them from pools and backwaters. Eggs of reptiles buried on sandbars and islands may be inundated and drown. Ground nesting birds in riparian habitats may also experience high mortality of nest and nestlings.

Just as altering the flood timing and duration may impact riparian ecosystems, so also will reducing the magnitude of flooding. Petts (1984) states that flood-control facilities, like Bluestone Dam, reduce normally higher winter flows and increase normally low summer flows. Over the course of a one-year cycle, these dams smooth out the variation that naturally occurs in a flood and drought cycle. Elimination or reduction in frequency of flooding limits opportunities for exchanges between the river and its former floodplain, so that processes that cause channel migration and construction of new wetlands and/or riparian areas is inhibited. Before the attenuation of flood peaks, the natural process was more effective (Norris 1992). Successional changes have already been documented where former riparian habitat is converting to stable upland communities (McDonald and Trianosky 1995). The greatest management concern associated with flow regulation may be insuring that riparian habitat remains in a condition of flood-scoured rocky and sandy riverbanks. This habitat supports most of the documented rare species at New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River (Norris 1992).

The U.S. Bureau of Land Management has developed guidelines and procedures to rapidly assess whether a stream riparian area is functioning properly in terms of its hydrology, landform/soils, channel characteristics, and vegetation (Prichard *et al*. 1998). This assessment, commonly called Proper Functioning Condition (PFC), is useful as a baseline analysis of stream condition and physical function, and it can also be useful in watershed analysis.

PFC is a methodology for assessing the physical functioning of a riparian-wetland area. It provides information critical to determining the health of a riparian ecosystem. PFC considers both abiotic and biotic components as they relate to the physical functioning of riparian areas, but it does not consider the biotic component as it relates to habitat requirements. For habitat analysis, other techniques must be employed.

PFC is a useful tool for watershed analysis. Although the assessment is conducted on a stream reach basis, the ratings can be aggregated and analyzed at the watershed scale. PFC, along with other watershed and habitat condition information, provides a good picture of watershed health and causal factors affecting watershed health.

Identifying streams and drainages where riparian areas along streams are not in proper functioning condition, and those at risk of losing function, is an important first step towards the ultimate goal of restoration. Physical conditions in riparian zones are excellent indicators of what is happening in a stream or drainage above.

With the results of PFC analysis, it is possible to determine stream corridor and watershed restoration needs and priorities. PFC results may also be used to identify where gathering more detailed information is needed, and where additional data are not needed.

PFC is not a quantitative field technique. An advantage of this approach is that it is less time-consuming than other techniques because measurements are not required. The procedure is performed by an interdisciplinary team and involves completing a checklist evaluating 17 factors dealing with hydrology, vegetation, and erosional/depositional characteristics. Training in the technique is required, but the technique is not difficult to learn. While mainly developed in the arid West, it is applicable to riparian areas of the East.

Two recommended actions address this issue. One proposal is more general, given the basic lack of knowledge about riparian zones in the three parks. This recommended action is **Assess Riparian Conditions in New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area**. The second recommended action, **Investigate Effects of River Regulation on Rare Plant Communities**, is more focused on a specific concern. This second recommended action also addresses concerns in the **Impoundments** issue.

Hazardous Spills and Waste Sites

Potential sources of hazardous materials and toxics include accidental releases by such means as train derailments, tanker-truck highway accidents, and spraying of herbicides along railroad right-of-way and include leachate and runoff from landfills, Superfund sites, industrial sites, and military sites. Other sources of hazardous and toxic materials previously discussed include municipal and industrial discharges and urban and agricultural runoff.

A main rail line of the CSX Railroad runs the length of New River Gorge and connects the chemical plants of Kanawha Valley to markets in the east and south. The National Park Service (1996a) documents four derailments in 10 years on this rail line. All of the derailments spilled only coal except one, which involved sulfated mercury. Three derailments have occurred in the last 5 years. Two involved coal and one of these introduced a small amount of oil into the New River. The third incident involved corn. Herbicides are sprayed on railroad property**,** after which they can be washed into New River by rains occurring immediately after spraying. Two major highways (I-64 and U.S. Route 19) and four smaller roads cross New River. Tanker-truck spills could easily reach New River (National Park Service 1996a). Bridges crossing New River within or just upstream of New River Gorge National River include: Highway 82 at Fayette; CSX Railroad near Sewell; CSX Railroad at Thurmond; Highway 25 at Stone Cliff; Highway 41 at Prince; CSX Railroad at Prince; I-64 near Sandstone; Highway 20 at Hinton; and Highway 3 at Hinton (Appel and Moles 1987).

A former line of the Nicholas, Fayette, and Greenbrier Railroad followed the left bank of Meadow River to its mouth and then the left bank of Gauley River to Peters Junction. There, it crossed the river and followed the rightbank to Gauley Bridge. Coal was the primary freight shipped on this railroad. The rail line is no longer in service, and the tracks have been removed. This line may become a rail-trail at a later date. No highways cross Gauley River or its floodplain in the park, but Meadow River is crossed by U.S. Route 19 at the upstream end of the park, as well as by many bridges upstream of the park, including one on Interstate 64. Contaminant spills could occur at any of these crossings.

Time of travel studies simulated the movement and dispersion of soluble and insoluble contaminants from such a spill through New River Gorge National River (Appel and

Moles 1987). This study produced ways to determine degree and time of passage of peak concentrations of contaminants at any point downstream from a chemical spill into New River. Later work calibrated models for solute transport in New River (Wiley and Appel 1989, Wiley 1992). The models provide a means of mitigation of contaminant spills by increasing streamflow with releases from Bluestone Dam (Wiley, 1993). No such information is available for Bluestone, Meadow, or Gauley Rivers. Of these rivers, Gauley River (with Summersville Dam) is the only one where a spill could be mitigated with streamflow manipulations. This concern is addressed by two recommended actions: **Determine Travel Time and Dispersion of a Conservative Solute for the Gauley River in Gauley River National Recreation Area** and **Determine Wave Propagation for the Gauley River in Gauley River National Recreation Area**.

An abandoned landfill located at the head of Rush Run and once operated by Fayette County may be leaking leachate into ground and/or surface water (National Park Service 1996a). This leachate could reach Rush Run and be transported to New River. Scattered illegal dumping occurs throughout southern West Virginia. Lighter trash easily washes into small streams from the illegal dumps. An examination of an online landfill database maintained by the West Virginia Division of Environmental Protection (1999c) revealed the existence in 1986 of several landfills and dumps in the counties of Fayette (28 sites), Mercer (22 sites), Nicholas (nine sites), Raleigh (eight sites), and Summers (eight sites). Landfills in these counties that are probably draining towards the park units include 10 in Fayette County (New River and possibly Meadow River), 20 in Mercer County (Bluestone River), two in Nicholas County (Gauley or Meadow Rivers), four in Raleigh County (New River), and six in Summers County (New River). Most but not all of these landfills were active in 1986. Several of the landfills active in 1986 are probably inactive today, and landfills opened after 1986 may need to be added to the database.

An online database of Superfund sites maintained by the U.S. Environmental Protection Agency (1999b) does not list such sites for any of the five counties in which the parks are contained. Reclaimed Superfund sites are not listed in this database. According to the water resources scoping report (National Park Service 1996a), the EPA directed the removal of over 4,700 tons of PCB-contaminated soil in 1987 and an additional 500 cubic yards of soil in 1990-91 from an abandoned transformer and capacitor rebuilding facility on Arbuckle Creek. Streambed sediments and fish tissue have not been checked for PCB concentrations.

Park personnel have reported effluent leaking from a closed military training site located within the park boundaries of New River Gorge National River (National Park Service 1996a). The U.S. Army Corps of Engineers once used this site to train engineers in the construction and demolition of floating bridges. The facility reportedly used an unlined grease pit to service vehicles, and residents observed a semi-truck dumping barrels into the pit and covering them. The park received funding to conduct a restricted phase II environmental site assessment for this location. The park built a campground at this site.

RECOMMENDED ACTIONS

Project statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify the additional staff and/or funds needed to carry out the proposed actions. They are planning tools used to identify problems and needed actions and are used to compete with other park projects for funds and staff. The following 24 project statements constitute the water resources management program for New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River.

Microbial Reconnaissance of New River Gorge National River

RMP Project Number: NERI-N-001.129
PMIS Number: 91433

Background

More than 200,000 visitors annually raft the whitewater rapids of New River Gorge National River. During hot summer days, rafters typically enjoy floating through swimmer's rapids, jumping from rocks along the river, and participating in numerous water battles between rafts. Even if these pursuits are avoided, all participants in the rafting trips are thoroughly soaked while negotiating the more challenging rapids, and a few unfortunate souls even experience a surprise dip in the river. Direct contact with the waters of the New River cannot be avoided during whitewater rafting expeditions.

Since 1985 the National Park Service and West Virginia Division of Environmental Protection have monitored fecal coliform bacteria densities at several New River mainstem and tributary sites. This monitoring has documented high concentrations of bacteria in many of the tributaries to New River (National Park Service 1996, Wilson and Purvis 2000). Several samples have produced densities greater than 100,000 fecal coliform colony forming units per 100 milliliters of water (>100,000 FC/100ml). Fecal coliform bacteria are derived from feces of warm-blooded animals (birds and mammals). Their presence is usually the result of inadequate sewage treatment. In many local cases sewage treatment is non-existent.

The presence of fecal coliforms indicates the potential presence of pathogens including bacteria, viruses, or protozoa (Britton and Greeson 1988). Many pathogens are more persistent than indicator bacteria in an aqueous environment, and once introduced into an aquatic environment can outlive indicator bacteria by several days. Pathogens have been reported in natural waters where indicator bacteria are not present (Benenson 1995). Even treated sewage may still contain pathogens that are much more resistant to treatment methods than fecal coliforms (Benenson 1995).

Sewage can contain a variety of pathogens including bacteria, protozoa, and more than 100 enteric viruses associated with human feces. Pathogens that could present significant health hazards in natural waters in West Virginia include *Giardia lamblia*, *Leptospira*, *Campylobacter*, *Salmonella*, *Shigella*, *Cryptosporidium*, *Cyclospora*, *Yersinia enterocolitica*, Norwalk agent, rotavirus, and hepatitis A (Carl Berryman, West Virginia Bureau for Public Health, personal communication 1999). All of these pathogens can be transmitted to humans through ingestion of contaminated water, and *Leptospira* can be transmitted by contact with contaminated water (Benenson 1995). A recent study by the West Virginia Office of Laboratory Services that examined stool samples from victims of diarrhea, found that *Giardia lamblia* and *Salmonella* were the most prevalent pathogens in infected stools (Frank Lambert, personal communication 1999).

Salmonella is found in contaminated food and water. If ingested they can cause acute illness manifested as diarrhea, vomiting, and other symptoms. *Cryptosporidium* is a protozoan found in human and animal feces and is transported in surface waters as an oocyst. The ingestion of from one to ten oocysts causes short-term diarrhea in healthy humans, but may cause a life-threatening, cholera-like illness in persons with weak immune systems (e.g. infants, the elderly, and persons with compromised immune systems). *Cryptosporidium* oocysts are highly resistant to routine chlorination and are small enough to escape removal by some filtration methods. Oocysts can survive for months in cool water. *Giardia lamblia* is a flagellate protozoan that exists in surface water as a cyst, may survive for months in cool water, and is more resistant to treatment than most bacteria. The ingestion of *Giardia* cysts causes diarrhea, but is not life threatening to healthy individuals. The water-transported enteric viruses can cause a wide array of diseases including polio, hepatitis, gastroenteritis, and innocuous infections (BioVir Laboratories 1998, Benenson 1995).

A limited-scope pilot study conducted in 2000 by the U. S. Geological Survey on two streams tributary to New River Gorge National River detected pathogenic organisms in both streams (Messinger 2002). Enteric viruses were detected in Madam Creek and Dunloup Creek. *Giardia lamblia* was detected in Dunloup Creek. *Clostridium perfringens* and male-specific coliphage were detected in Madam Creek. *Salmonella* and *Cryptosporidium* were not detected in either stream.

The results of this study suggest that more intensive and extensive research is needed to accurately document the presence of pathogenic microorganisms in New River Gorge National River, and to relate the presence and concentrations of these organisms to the indicator, fecal coliform bacteria. The pilot study used the best available commercial methods for identifying and enumerating pathogenic organisms. However, these methods were developed for regular monitoring of water treatment facilities or documenting causes of disease outbreaks. These methods produced some ambiguous results in the New River Gorge study. A more comprehensive analysis is necessary.

<u>Description of Recommended Project or Activity</u>

The objectives of this study are to: 1) develop and test methods of collecting representative water samples for analysis of indicator bacteria and pathogens; 2) relate pathogens to indicator bacteria; 3) determine the best type(s) of indicator bacteria for predicting the presence of pathogens in the New River and its tributaries; and 4) document possible human health hazards during recreational activities (especially whitewater boating) due to direct contact with river water containing pathogens. The presence or absence and relative amounts of selected pathogens will be determined for natural waters in the New River and selected tributaries along sections of the New River Gorge most often frequented by rafters and kayakers. No data of these types presently exist.

Selected pathogens will be sampled at sites previously monitored for bacteria in the New River and its tributaries. Samples will be collected and analyzed according to U. S.

Environmental Protection Agency (EPA) approved and standard methods at EPA approved independent laboratories, and will include the bacteria *Salmonella*, the protozoa *Cryptosporidium* and *Giardia lamblia*, and total culturable viruses. *Salmonella* will be determined from chilled water samples mailed immediately to the lab for the culturing (SM18; 9260B). *Cryptosporidium* and *Giardia lamblia* will be determined by fluorescence assay (EPA 600/R-95/178) from filter units mailed to the lab. Total culturable viruses will be determined from filter units by the information collection rule method (EPA 600/R-95/178). Samples exceeding the virus detection limits will be sent to specialized labs for further identification and/or culturing of specific viruses. Indicator bacteria, including fecal coliform, enterococci, and *Escherichia coli* will be collected concurrently and evaluated as to their reliability in predicting pathogens. Stream discharge, specific conductance, pH, turbidity, water temperature, and dissolved oxygen will be collected at each site for reference and to document current stream conditions. Samples will be collected at base flow at the mouths of tributaries to the New River and at main stem sites in the summer during peak usage of the New River by rafters. Additional samples will be collected during storm events at tributary sites. Tributary sites will be chosen from sites with high fecal coliform concentrations as previously determined by the National Park Service and West Virginia Division of Environmental Protection. Both tributary and main stem sites will be selected in river reaches frequented by commercial whitewater outfitters.

A number of benefits will result from this study including the following: 1) determine presence or absence of a number of pathogens in the New River and its tributaries within New River Gorge; 2) determine relationships between pathogens and indicator bacteria concentrations in streams; 3) determine which bacteria is the best indicator of pathogens in the New River and its tributaries; and 4) initiate a database for evaluation of stream conditions most likely to support pathogens. These benefits would address major needs of the park including development of standards for warning the public of potential health hazards for primary contact water recreation, and the evaluation of other methods for assessing health hazards due to sewage pollution.

<u>Literature Cited</u>

Benenson, A. 1995. Control of communicable diseases manual. American Public Health Association, 577 pp.

BioVir Laboratories. 1998. Cryptosporidium. Benecia, CA, 7 pp.

Britton, L. and P. Greeson. 1988. Methods for collection and analysis of aquatic biological and microbiological samples. Open-File Report 88-190, U. S. Geological Survey, pp. 3-95.

Messinger, T. 2002. Reconnaissance for selected pathogens, and review of pertinent literature, for the New River Gorge National River, West Virginia, 2000. Open-File Report 02-65, U. S. Geological Survey, 12 pp.

National Park Service. 1996. New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River, West Virginia, Water Resources Scoping Report. Technical Report NPS/NRWRS/NRTR-96/76, 24 pp.

Wilson, L. and J. Purvis. 2000. Water quality monitoring program, 1994-1997, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV, 154pp.

Proposed Budget

There is potential for an Interagency Agreement with U. S. Geological Survey, Water Resource Division, Charleston, West Virginia District for a detailed two-year study. Year one costs are estimated at $100,000, and year two costs are estimated at $50,000. These are preliminary estimates provided by the U. S. Geological Survey. More detailed funding estimates will be developed later. Potential funding options include NPS/USGS Water Quality Partnership and National Park Service NRPP.

Epidemiological Survey of Recreational Water Users in the New and Gauley Rivers

RMP Project Number: NERI-N-001.113
PMIS Number: 91434

Background

Visitation to New River Gorge National River and Gauley River National Recreation Area has increased greatly since 1985. As a result, more persons are coming into direct contact with waters of the New and Gauley rivers in the pursuit of recreational activities such as rafting, fishing, kayaking, canoeing, and swimming. The number of annual visitors to New River Gorge National River has increased from 263,961 in 1985 to 1,240,037 in 1996. The number of visitors to Gauley River National Recreation Area was 214,880 in 1996.

Approximately 250,000 people partake of whitewater boating on the New and Gauley rivers each year. Participants have significant contact with contaminated river water during the trips. A typical raft includes activities such as swimming through rapids, diving into the river from adjacent rocks, and numerous water fights to keep cool on hot summer days. Waves pound the faces of participants in the front of the boats, and rafters are thrown overboard while navigating difficult rapids.

Many of these persons are coming into direct contact with waters of the New and Gauley rivers and their tributaries. Fecal coliform and *Escherichia coli* bacteria samples collected in the New and Gauley rivers and their tributaries (Wilson and Purvis 2000) frequently have produced concentrations far in excess of the West Virginia standard for water contact recreation (46 CSR 1). Thus these data indicate a possible risk of health hazards. Health risks include dysentery, typhoid, and hepatitis.

Gathering information on the health of rafters, and possibly other recreational users, for a period of time immediately following recreational water contact would help describe and define the actual health risks present.

Description of Recommended Project or Activity

A survey of rafters who have just completed rafting trips down the New and Gauley rivers is proposed to describe health problems encountered after the trip and thus to define actual health risks associated with recreational contact with waters of these rivers. A phone survey is proposed. Such a survey would require the cooperation of commercial whitewater outfitters by providing lists of rafters and their phone numbers, and by collecting samples along the trip. The questions would be designed to describe the overall rafting experience, and include questions that would describe any health symptoms such as diarrhea, vomiting, or fever that could be associated with water-borne pathogens.

Arrangements would be made in advance with rafting companies to obtain lists of names and phone numbers for rafters scheduled for selected dates. Individuals would be asked to volunteer to take part in a scientific study. Fecal coliform and *E. coli* samples would be collected from the rafts by trip guides in sterile bottles provided to them, and would be stored on ice until transferred to park personnel on shore. Park personnel would transport samples to the park laboratory, or an independent laboratory, for analysis.

About a week after the trip, rafters volunteering to take part in the study would be contacted by phone and asked questions from a professionally designed questionnaire. A week should be enough time for intestinal symptoms to appear in infected rafters and still be fresh in their memories. A comparison of the health symptoms and the bacteria samples collected during the rafting trips could indicate actual health risks. An alternate and more voluntary means of surveying rafters would be to hand to rafters after their trip stamped questionnaire cards addressed to the park to be returned in one week. This would be less invasive to the privacy of rafters, but would probably produce a smaller data set that could possibly be biased towards individuals who experienced health problems.

Literature Cited

Wilson, L. and J. Purvis. 2000. Water quality monitoring program, 1994-1997, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV, 154pp.

Proposed Budget

This proposal is preliminary at this time. There are several potential methods to accomplish the project. These include: 1) Interagency Agreements with either the U. S. Geological Survey, Water Resource Division, Charleston, West Virginia District, the U. S. Centers for Disease Control, or the West Virginia Bureau of Public Health; 2) in-house by the National Park Service; or 3) a third-party contract with an appropriate vendor. The U. S. Geological Survey envisions a one-year study that would cost approximately $50,000.

Determine Animal Sources of Fecal Bacteria in New River Tributaries

RMP Project Number: NERI-N-001.111
PMIS Number: 88050

Background

More than 200,000 visitors annually raft the whitewater rapids in New River Gorge National River. During hot summer days, rafters typically enjoy floating through swimmer's rapids, jumping from rocks along the river, and participating in numerous water battles between rafts. Even if these pursuits are avoided, all participants in the rafting trips are thoroughly soaked while negotiating the more challenging rapids, and a few unfortunate souls even experience a surprise dip in the river. Direct contact with the waters of the New River cannot be avoided during whitewater rafting expeditions.

Since 1985 the National Park Service and the West Virginia Division of Environmental Protection have monitored concentrations of fecal coliform bacteria at several main stem sites and tributaries to New River. This effort has documented frequent concentrations of bacteria in both the New River and many of its tributaries that violate West Virginia standards for primary contact water recreation (National Park Service 1996, Wilson and Purvis 2000). Some tributary samples have exceeded 100,000 fecal coliform per 100 milliliters of water. High concentrations of fecal coliform bacteria can indicate the possible presence of pathogenic (disease causing) organisms including bacteria, viruses, or protozoa (Britton and Greeson 1988). A major suspected source of the fecal bacteria found in tributaries to the New River are treatment facilities and communities that at times discharge untreated or partially treated sewage into these tributaries. Bacteria source tracking could verify this suspected source and determine other sources of fecal bacteria in these streams.

Sewage influent can contain a variety of pathogens, including bacteria (e.g. *Shigella* and *Salmonella*), protozoa (e.g. *Cryptosporidium* and *Giardia lamblia*), and more than 100 enteric viruses associated with human feces. Pathogens that could present significant health hazards in natural waters in West Virginia include *Giardia lamblia*, *Leptospira*, *Campylobacter*, *Salmonella*, *Shigella*, *Cryptosporidium*, *Cyclospora*, *Yersinia enterocolitica*, Norwalk agent, rotavirus, and hepatitis A (pers. comm., Carl Berryman, West Virginia Bureau for Public Health, 1999). All of these pathogens can be transmitted to humans through ingestion of contaminated water, and *Leptospira* can be transmitted by contact with contaminated water (Benenson 1995). A recent study by the West Virginia Office of Laboratory Services examined stool samples from victims of diarrhea. The study found that *Giardia lamblia* and *Salmonella* were the most prevalent pathogens in the infected stools (pers. comm., Frank Lambert, West Virginia Office of Laboratory Services, 1999). A recent pilot study confirmed the presence of several pathogens in the two streams sampled that are tributary to New River Gorge National River (Messinger 2002).

Objectives: The objectives of this study are to: 1) develop source libraries of *Escherichia coli* (*E. coli*) isolates for the purpose of identifying the animal sources of fecal bacteria in ambient water samples; 2) determine animal sources of the fecal bacteria found in water samples from four selected tributaries to the New River; and 3) analyze differences in strains or isolates of *E. coli* bacteria cultured from human and animal feces in the New River Gorge area versus strains or isolates of *E. coli* bacteria cultured from human and animal feces in Berkeley County in the eastern panhandle of West Virginia. If the bacteria isolates for these two geographical regions of West Virginia are similar, they will be combined into one source library with Statewide and possibly regional application.

<u>Description of Recommended Project or Activity</u>

Approach: During the summer of FY2003, feces samples will be collected from humans, deer, geese, and dogs in the New River Gorge area. A minimum of 50 scat samples will be collected from each of these four animal sources. Each scat sample will be carefully pulled apart by sterile toothpicks and a small amount of the center of the scat mass will be removed by a sterile toothpick and will be swirled in a vial of sterile buffer that will be labeled as to animal source. These vials will be promptly chilled and will be shipped daily by overnight mail to three bacteria source tracking researchers. Each of these researchers will culture and confirm a total of 100 *E. coli* bacteria isolates for each of the four animal sources. Each researcher will then perform a different type of bacteria source tracking analysis on the 100 bacteria isolates to build a source library for the New River Gorge area. The three source tracking methods will be chosen, based in part, on method performance of seven source tracking methods now being compared in a current study in Berkeley County, West Virginia, and, in part, on method cost. The proposed budget will allow for one genotypic method such as ribotyping or Rep-PCR and two phenotypic methods such as carbon source utilization by BIOLOG and antibiotic resistance analysis. Researchers will send the raw data from each bacteria analysis to the USGS microbiology laboratory in Columbus, Ohio. In FY2004, the raw data will be compared to the raw data obtained from the same four animal sources (humans, dogs, geese, deer) in Berkeley County, West Virginia, to determine possible differences in bacteria strains and thus the geographical variability for each bacteria source tracking method. A journal article will be prepared in FY2004 describing the comparisons of the bacteria isolates cultured from feces in the New River Gorge area versus those bacteria isolates cultured from feces in Berkeley County.

During the summer of FY2004, water samples will be collected in four streams that are tributary to the New River and that contain relatively significant concentrations of fecal bacteria as documented by water-quality monitoring performed for several years by the Park. The tributaries to the New River suggested by the Park for bacteria sampling include Dunloup, Wolf, Arbuckle, and Keeney creeks. Water samples from these streams will be filtered, and bacteria colonies will be plated on site. After proper incubation, the filters containing the bacteria colonies will be chilled and shipped by overnight mail to the researcher who will be performing a selected bacteria source tracking analysis. For each stream site, 150 *E. coli* isolates will be cultured and confirmed from the plated bacteria filters. These isolates will be compared with the isolates in the source library and a presumptive identity of animal source will be established when possible for each isolate. Isolates will be classified to source as human, dog, deer, goose, or other source. A U.S. Geological Survey Water-Resources Investigations Report will be written in FY2005 that describes animal sources of the fecal bacteria in each of the four streams.

Benefits: A number of benefits will result from this study including the following: 1) determination of the animal sources of the fecal bacteria in several streams tributary to the New River Gorge which will aid in the eradication of these sources; 2) establishment of bacteria source libraries for the New River Gorge area for three major bacteria source tracking methods that will facilitate future bacteria source tracking analyses in the New River Gorge area; and 3) possible development, depending on the outcome of the geographical comparison of isolates, of a regional source library of *E. coli* bacteria isolates or strains in four animal sources in West Virginia that will aid State water agencies in developing bacteria-based TMDLs.

Literature Cited

Benenson, A. 1995. Control of communicable diseases manual. American Public Health Association, 577 p.

Britton, L. and P. Greeson. 1988. Methods for collection and analysis of aquatic biological and microbiological samples. U.S. Geological Survey Open-File Report 88-190.

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Wilson, L. and J. Purvis. 2000. Water quality monitoring program, 1994-1997, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV.

Proposed Budget

Cost: FY 2003 - $100,000 ($85,000 from program, $15,000 additional funds will be supplied by West Virginia District, the Park will supply labor with estimated value of $7,000 net).

FY 2004 - $100,000 ($85,000 from program plus same additional funds and labor as in FY2003).

FY 2005 - $40,000 ($35,000 from program, $5,000 additional funds will be supplied by West Virginia District, the Park will supply labor with an estimated value of $7,000 net).

Category	FY 2003	FY2004	FY2005
Labor	28,000	27,000	22,000
Publication Costs		1,000	1,000
Travel	2,000	2,000	
Vehicles	3,700	3,600	
Postage	1,000	1,000	
Laboratory analyses	27,000	25,000	
Supplies	1,000	2,000	
Net Costs	62,700	61,600	23,000
Gross Costs	100,000*	100,000*	40,000*

*Funding:

Funding source	FY2003	FY2004	FY2005
National Park Service/USGS Program	85,000	85,000	35,000
USGS West Virginia District	15,000	15,000	5,000

Note: This project was selected for funding by the National Park Service NRPP Program in 2002.

Technical Evaluation of Water Quality Monitoring Program

RMP Project Number: NERI-N-001.114
PMIS Number: 91435

Background

History

In 1980, two years after the creation of New River Gorge National River, the National Park Service recruited the West Virginia Department of Natural Resources to monitor water quality in the newly created park to establish baseline conditions. Parameters monitored were fecal and total coliform bacteria, temperature, specific conductance, pH, dissolved oxygen, biological oxygen demand, alkalinity, nutrients, major cations, anions, and metals for six main stem and nine tributary sites from 1980 to 1984 (Wood 1990a). These data showed high fecal coliform counts.

In 1985 to 1986 the National Park Service sampled fecal coliform bacteria at 12 sites on the New River and eight tributary sites. In 1985 park staff used quick and inexpensive Coli Counters that were not approved by the U.S. Environmental Protection Agency (EPA). In 1986 samples were analyzed at a local U.S. Department of Agriculture laboratory that used the EPA-approved membrane-filter method.

In 1987 responsibility for water quality monitoring was returned to the West Virginia Department of Natural Resources. Fecal coliform samples were collected at nine main stem sites and five tributary sites in 1987, at nine main stem and six tributary sites in 1988, and at six main stem and 10 tributary sites in 1989 (West Virginia Department of Natural 1989). In addition to fecal coliform, other constituents monitored included metal cations (total iron, manganese, and aluminum) sulfate, dissolved and suspended solids, temperature, dissolved oxygen, specific conductance, and pH (Wood 1990b).

Since 1990 the National Park Service has maintained responsibility for the water quality monitoring program. This program now includes Bluestone National Scenic River and Gauley River National Recreation Area. Both of these areas were added to the National Park System in 1988.

The number of sites monitored in New River Gorge National River has varied, with new sites added, and some sites being discontinued, as conditions warrant. Five sites are monitored in each of Gauley River National Recreation Area and Bluestone National Scenic River. In each of these two parks, three sites are on the main stem rivers, and two on tributaries. A total of forty-one sites will be monitored in the three parks during 2003.

Program

The ongoing program primarily focuses on fecal coliform bacteria. Air and water temperature, pH, specific conductance, and dissolved oxygen are also measured on bacteria sampling runs. The park laboratory analyzes most samples. For quality control purposes, some samples are split, with portions analyzed by one or more local private testing laboratories.

The frequency of bacteria sampling has varied. Prior to 1998, each site was sampled biweekly. In 1998 sampling frequency was reduced to monthly to allow for more intense sampling of storm events at one site, Dunloup Creek. In 2002 an extensive storm-event sampling regime began in response to the floods of 2001.

To evaluate the incidence of acid mine drainage, the metal ions total aluminum, iron and manganese, along with alkalinity and pH, have been collected quarterly. The frequency of this sampling recently was reduced due to a general lack of acid drainage in the area of the parks. This is because of the mostly low-sulfur coal produced in the extensive mining that occurred in the region. A few abandoned mine sites and processing facilities show evidence of acid drainage, and these sites are monitored more frequently.

To calculate constituent loadings, discharge is determined from two continuous stream flow gages on the New River, and one each on the Bluestone and Gauley rivers. Staff gages at eight tributary sites provide estimates of instantaneous discharge for these streams. The U. S. Geological survey maintains all of the gages, and updates stage-discharge relationships by taking stream flow measurements.

All water quality data are stored in a Microsoft Access database maintained at park headquarters. All data collected from 1980 to 1994 have been up-loaded to the U. S. Environmental Protection Agency's STORET database. Data collected since 1994 have not yet been up-loaded to STORET.

The annual water quality monitoring budget for the parks approaches $200,000. This includes personnel costs (four FTE), laboratory and field sampling equipment and expendables, and the cost of having some samples analyzed by outside laboratories.

<u>Issues</u>

The park's water quality monitoring program has evolved over time, often in response to crises. Park staff assigned to aquatic resources are usually so busy with a variety of issues that time to evaluate the appropriateness and effectiveness of ongoing programs, including water quality monitoring, is not available.

Because these three river-based parks cover an extensive area with many streams, decisions on where, when (including how often), what and how to sample, are critical. For example, collecting lots of samples at a few locations leaves other areas unmonitored. Collecting samples over a wide area often does not provide detailed information about water quality dynamics at a particular site. Historically, the park has opted for the latter, a widespread, extensive sampling network.

The West Virginia standard (46 CSR 1) for fecal coliform bacteria relevant to primary water contact recreation (including boating) is based on the monthly geometric mean of no less than five samples. If the geometric mean of the samples exceeds 200 fecal coliforms per 100 milliliters of water (>200FC/100ml), the site is deemed in violation of the standard. The alternative state standard is more than 400FC/100ml in no more than 10% of the samples taken within a month. Obviously it is easier to prove a violation exists using the lower standard, but sampling that often would result in other sites being sampled less often, and other water resource program responsibilities being neglected.

Efforts at more intensive sampling have occurred in recent years. Since many of the monitoring sites have provided data for ten or more years, good baselines of data and conditions have been developed. This has allowed park staff to focus some energy on specific problem areas. However, growing concern about the widespread extent of fecal pollution in the New River watershed, and the possible impact of this pollution on human health and the water-based recreational tourism industry, has resulted in many requests for intensive sampling efforts. Obviously, not all of these requests can be met with existing funding and staffing levels.

The park has collected little information on the potential impacts of water quality conditions on aquatic biological resources. These resources can be assessed using a suite of multimetric indexes that has become known as ‘rapid bioassessment’ techniques. Such comprehensive, multimetric indexes (Barbour *et al*. 1995) were first developed in the Midwest for use with fishes (Karr 1981, Fausch *et al*. 1984, Karr *et al*. 1986) and modified for use with invertebrates (Plafkin *et al.* 1989, Kerans and Karr 1994, Deshon 1995, Fore *et al*. 1996). Similar approaches are now applied to a variety of aquatic environments (Davis and Simon 1995), including large rivers, lakes, estuaries, wetlands, riparian corridors, and reservoirs, and in a variety of geographic locations. Rapid bioassessment techniques offer a cost-effective way to monitor and assess aquatic biological resources, but determining which of many possible disturbances are affecting aquatic communities is more difficult. However, including some form of biological monitoring in future water quality monitoring efforts may serve as a valuable, inexpensive ‘red-flag’ warning system.

The park completed a trial macroinvertebrate-based rapid bioassessment technique for New River tributary streams. No follow-up work has occurred. A fish-based index of biotic integrity was developed for New River tributary streams (Leonard and Orth 1986) with assistance from the National Park Service. Due to other workloads, the parks have not yet attempted to apply this research.

A rigorous, integral quality assurance/quality control (QA/QC) program is required to validate the quality of results from any data-collection effort. An effective QA/QC program demonstrates the professionalism of the effort, the reliability of the results, and enhances the potential for positive judicial scrutiny in any relevant legal proceedings.

The parks use a variety of QA/QC procedures in the water quality monitoring program. These procedures are not formally documented in a single QA/QC plan, and are not regularly reviewed and updated. Examples of QA/QC procedures used by the park include following standard published methods for sample collection, handling and analyses, equipment maintenance and standardization, and reporting of results, and analysis of split samples by independent laboratories.

Aquatic resources data management in the park has been criticized (Smith and Marini 1998). Land use data such as locations of oil and gas wells, abandoned mines and mine drains, sewage outfalls, and logging tracts in or near the parks have not been accurately and completely compiled. Land ownership records are maintained only in paper files in the National Park Service Northeast Region Lands Office in Oak Hill, WV. The National Park Service could more effectively manage water resources of the three parks with a data storage and management system that would allow easy access to, and the ability to interrelate, water quality, land use, and land ownership data.

Recent upgrade of the park's water quality data storage and management from a dBase to a Microsoft Access database has helped, as has the development of a GIS program in the park. Integration of these two programs is planned for the near future. Items to be considered in this integration include: existing GIS coverages; other coverages needed; integrating water quality data with other data in a useful and meaningful manner; and the possibility of storing all water-resource data in one database for data management efficiency.

The park also needs to explore methods of making its water resources data more readily available to the public. One step would be to upload more recent data to STORET or the U. S. Environmental Protection Agency's new LDC database. The park is also exploring how to make water quality and aquatic biological data available over its web page.

Description of Recommended Project or Activity

A three-phase process is recommended to address issues related to the parks' water quality monitoring program. Phase I would be an initial review. Phase II would be the incorporation of comments generated by Phase I. Phase III would be on ongoing review of the new program.

For Phase I, an interdisciplinary team of experts knowledgeable about water quality monitoring issues will be assembled to evaluate the parks' water quality monitoring program. This team shall be composed of members from within and outside of the National Park Service. Members from within the agency shall include appropriate park personnel and employees of the National Park Service's Northeast Region and Water Resources and Biological Resources Divisions. Team members from outside the agency shall include representatives from the Water Resource and Biological Resource Divisions of the U. S. Geological Survey, the West Virginia Departments of Natural Resources and Environmental Protection, local watershed groups, area organizations interested in water resource issues, and area universities. An independent facilitator will lead the team.

The workshop will be held at park headquarters. Subject areas to be evaluated include the appropriate mix of physical, chemical and biological monitoring, methods, monitoring effort and timing, technical and scientific credibility, data management, effectiveness in meeting management needs, and cost-effectiveness.

Specific aspects of technical credibility to be addressed include QA/QC, thoroughness and adherence to protocols, documentation of findings, relevance of data collected to study goals, communication of findings, and management support of the water quality program. Specific aspects of effectiveness in meeting management needs to be addressed include timeliness and frequency of data reporting, relevance of program activities to present major water quality issues and the relation among management objectives, land and water use issues, and the sampling program design. Cost-effectiveness assessment will primarily address whether or not the importance of issues and objectives is consistent with effort expended, but also whether alternative methods are available to adequately address those problems and objectives.

The initial workshop will be a weeklong event. On the first day, park management will provide a short, well-focused list of critical management objectives and descriptions of how the water quality monitoring program has contributed, either adequately or not, to meeting these objectives. Three full days will be spent on technical review of monitoring, survey, and data management protocols and procedures. On the final day, the review team will present their findings to park management and aquatic resources staff. There will be an opportunity for park staff to discuss the findings and recommendations, and to clear up misconceptions the review team may have formed. The overall objective of this workshop is to provide enough information and guidance that the park can develop an effective, responsive water quality monitoring plan.

Within three months after the initial review, the review team will produce an informal, internal report that will serve both as minutes of the review, and document the recommendations of the review team. This document will be starting point for the developing the water quality monitoring program plan.

In Phase II the park will evaluate the recommendations of the review team, and implement any changes that are considered appropriate. All changes adopted will be documented to provide an accurate historical record of the water quality monitoring program.

Phase III will be a periodic re-evaluation of the parks' water quality monitoring program. The first re-evaluation will be conducted by Phase I review-team members. This follow-up will occur within one year of the initial review, and will evaluate the parks' draft water quality monitoring plan and any changes already implemented. It may be possible to conduct this review using postal and teleconferencing methods, rather than an actual site visit.

Later reviews will be even less formal, and should occur on an annual basis. These reviews will also have less outside input. The periodic reviews will address the same issues as the initial technical evaluation workshop and serve as a feedback loop to park management and staff of the adequacy of the currently implemented water quality monitoring program.

The proposed budget covers travel costs for non-park participants, some remuneration of time spent by workshop participants (may include honorariums); workshop materials, fee for facilitator, and document review time.

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Proposed Budget

Personnel Costs		$17,910
Reviewers	$14,910	
(9 equivalent to GS-12, 40 hours)		
Facilitator	$3,000	
Travel and Per Diem		$4,250
10 people at $55 lodging and $30 M&IE for 5 nights		
Rental vehicles for reviewers		$1,100
Supplies and Equipment		$1,000
Overhead		
(outside agencies – 15%)		$1,240
Total		**$25,500**

Park contribution $12,231 (48%)

Superintendent (GS-15; $1,116), Deputy Superintendent (GS-13; $788): 2 days each for initial and final meeting, follow-up review.

Resource Management Specialist (GS-12; $1,657): 5 days for initial and final meeting, oversight of plan development and periodic reviews

Biological Technicians (3x GS-5; $4,523): 10 days each for initial and final meeting, plan development, periodic reviews.

Fishery Biologist (GS-11; $4,147): 15 days for entire initial review, plan development, follow-up review, periodic reviews.

Note: all personnel costs are based on mid-step of grade, include benefits at 35%, and proposed 4.1% CY03 pay raise.

Determine Stream Flow Characteristics of New River Tributary Streams

RMP Project Number: NERI-N-001.115
PMIS Number: 60865

Background

New River Gorge National River consists of a relatively narrow 53-mile corridor along New River. Over 250,000 people each year enjoy the exceptional whitewater boating opportunities within the park, and an additional large number of anglers partake of the eastern US's most productive warm-water fishery.

Within the park, 17 major tributaries enter New River. Many of these streams enter New River at or near access sites used by anglers, and put-in and take-out sites heavily used by whitewater boaters, including over two dozen commercial outfitters. Most of these streams' watersheds drain private land. These lands are used for mineral (coal, oil, and gas) extraction, timbering, low intensity agriculture, and commercial development. Several cities and towns, and numerous dispersed rural residential areas exist in these watersheds.

These streams often carry human fecal material from inadequately treated sewage (e.g. untreated direct discharge, failed septic systems, overloaded sewage treatment plants) into New River. Other contaminants may include sediment, nutrients, sulfate, and metals. Movement of these contaminants, especially fecal bacteria, within the tributaries and into New River is determined by local, small-stream hydrology.

During low flows, fecal bacteria concentrations in New River are usually small, often below the West Virginia standard for primary contact water recreation of 200 fecal coliforms per 100ml (FC/100ml) of water. However, during high flow events on tributary streams, usually caused by localized heavy rainfall, bacteria concentrations may exceed 100,000 FC/100ml. During high flow events these streams may contribute the majority of the fecal bacteria present in New River (Purvis and Wilson 1999, Wilson and Purvis 2000, 2002, Vandersall and Purvis 2003). These high flow events significantly raise the potential health hazard to park visitors to fecal-related water-borne diseases.

The relationship between stream discharge and fecal bacteria concentrations, especially during individual storm/runoff events, is not linear and straightforward (Elder 1987, Purvis and Wilson 1999). Fecal bacteria from non-point sources typically are flushed into streams early in a runoff event, with peak concentrations usually occurring during the rising limb of a hydrograph (before peak discharge). Because of the variety of fecal bacteria sources in New River Gorge National River, the relationship between discharge and bacteria concentrations is even more complex. In order to make effective management decisions to protect park aquatic resources and visitor health and safety, in-depth knowledge of tributary stream hydrology is essential.

Description of Recommended Project or Activity

This program has several objectives:

- provide detailed information on the hydrologic dynamics of streams tributary to New River within New River Gorge National River;
- provide detailed information on the rainfall dynamics in this area;
- correlate the above information to develop detailed information on the relationships between rainfall and stream discharge;
- correlate all of this with water quality information to produce detailed; and information on the hydrologic relationships of fecal bacteria in these streams.

The U. S. Geological Survey (USGS) maintains two continuous, recording stream gages on New River, and eight non-recording stage gages on tributaries, within New River Gorge National River. The tributary gages are used to estimate instantaneous discharge at a particular time (e.g. when a water quality sample is collected), but they do not provide continuous records. A continuous recording stream gage will be installed at one of the existing tributary sites. This information would be correlated to stage and discharge measurements made on this and other tributaries to better understand the hydrologic dynamics of these small streams. Water quality samples would be correlated with hydrologic status at the time of sample collection to provide detailed information on the relationship between tributary hydrology and the magnitude and timing (loading) of fecal contamination.

The site selected for installation of the recording gage will be mutually agreeable to USGS and the National Park Service. The gage will be rated and maintained by USGS according to standard procedures (Carter and Davidian 1968, Buchanan and Somers 1968, 1969, Kennedy 1984). The recorder will be equipped with a satellite transmitter and transmit preliminary data every four hours that automatically will be uploaded to the USGS web site. A telephone-accessible, real-time output system will be installed to allow USGS and park staff to retrieve time-sensitive stage data. Final data will be published annually in the Water-Data Series (e.g. Ward *et al*. 1999).

Additional items will further expand the usefulness of this project. Crest-stage gages will be installed at the other seven tributary stage gage sites. These will allow accurate determination of the magnitude and timing of peak discharge events on those streams. Also, the frequency of stage-discharge measurements at these sites will be increased to eight times per year. This will provide more accurate stage-discharge relationships for these streams. The existing rain gage at park headquarters will be upgraded to a recording gage, and additional recording rain gages will be installed at the Canyon Rim and Sandstone Visitor Centers. These will provide detailed information on the timing and intensity of rainfall events, and will help to more accurately correlate runoff dynamics with rainfall. Information from the recording rain and stream gages, along with information on watershed area and land use, will allow the generation of synthetic stream flows for the ungaged watersheds in this area (Searcy 1960, Evaldi *et al*. 1993).

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Proposed Budget

These figures comprise an estimate based on information provide by USGS. More detailed costs will be developed at a later date.

Year 1: $86,000
Site selection, purchase & install equip., develop prelim. ratings, publish results.
Year 2: $70,000
Maintain equipment, refine ratings, prelim. synthetic discharges, publish results.
Year 3: $87,500
Maintain equipment, refine ratings and synthetic discharges, produce final report.

Total $243,500

Develop Long-term Monitoring Program for Gauley River National Recreation Area

RMP Project Number: NERI-N-001.116
PMIS Number: 91437

<u>Background</u>

Gauley River National Recreation Area was established in 1988 by PL 100-534 to "protect and preserve the scenic, recreational, geological, and fish and wildlife resources of the Gauley River and its tributary, the Meadow River." Gauley River National Recreation Area contains 25.5 miles of the Gauley River from the tailwaters of Summersville Dam downstream to near its confluence with the New River, and the lower 5.5 miles of the Meadow River. The National Park Service manages Gauley River National Recreation Area from New River Gorge National River headquarters in Glen Jean, West Virginia.

Gauley River within Gauley River National Recreation Area contains the greatest density of Class V rapids of any river east of the Rocky Mountains. This world-class whitewater is the park's major draw. Since its creation, Gauley River National Recreation Area has seen a dramatic increase in the number of rafters and kayakers running the Gauley and Meadow Rivers. At the Summersville Dam tailwaters, pproximately 17,000 people launched onto the Gauley River in 1984, while over 40,000 people launched in 1996. These numbers may be 25% below actual use (Warren Snyder, New River Gorge National River, personal communication 2000). An unknown number of kayakers run the highly technical Meadow River. Gauley River is also heavily fished year-round, and the West Virginia Department of Natural Resources regularly stock trout in the tailwaters below Summersville Dam. Increasing visitor use is putting an unknown strain on the aquatic resources of Gauley River National Recreation Area and exposing a greater number of people to potential health hazards from contaminated water.

Visitors to Gauley River National Recreation Area may be at risk from contact with inadequately treated domestic wastewater discharged into Gauley River and its tributaries. The lack of adequate septic or sewer systems is prevalent throughout Appalachia and especially southern West Virginia. The increasing use of Gauley River, and the inevitability of water contact for whitewater enthusiasts and anglers, makes this problem especially acute.

Activities which may impact water resources in Gauley River National Recreation Area include mining (especially mountaintop removal - valley fill operations), timbering, recreational and industrial development, and oil and gas exploration and development. The recently completed installation of a power generation facility at Summersville Dam may also impact water resources in Gauley River.

Despite heavy use levels, relatively little is known about Gauley River water quality and aquatic biological resources. Available information is disparate and widely scattered. In order to manage Gauley River National Recreation Area effectively, the National Park Service needs high quality, systematic information on the status and trends of aquatic resources in the park.

The National Park Service currently conducts limited water quality monitoring in the Gauley River watershed. As part of their routine monitoring of water quality for public health, fecal coliform bacteria are sampled at five sites within the park. Before 1998 sampling occurred roughly biweekly during the summer. This provided a reasonable estimate of low water, baseflow conditions. Since 1998, changes in the focus of the water quality monitoring program have led to samples being collected from the established Gauley watershed sites less frequently. The National Park Service also has developed limited data on dissolved metals, primarily iron, manganese, and aluminum, for the purpose of evaluating potential acid mine drainage problems.

Other information on the aquatic resources and water quality of the Gauley River watershed is available, but much of it is dated. The U. S. Geological Survey, in cooperation with the West Virginia Geological and Economic Survey, carried out a baseline water-chemistry study of the Gauley River watershed in 1978-81. The ground-water data from this study were incorporated into an interpretive map (McAuley 1985). A report discussing the effects of coal mining in this region used some of the surface-water data from this study (Ehlke *et al.* 1982). The U. S. Fish and Wildlife Service (1977) surveyed invertebrate communities in the Gauley River downstream from Summersville Dam. Hocutt *et al.* (1979) conducted fish surveys throughout the Gauley watershed. Land-use data based on aerial photography surveys flown in 1973 are available (McColloch and Lessing 1980). The National Park Service compiled existing water quality data relevant to Gauley River National Recreation Area from the U. S. Environmental Protection Agency's STORET database (National Park Service 1995).

The Kanawha-New River National Water Quality Assessment (NAWQA) Program of the U. S. Geological Survey (Hirsch *et al.* 1988, Eychaner 1994, Messinger 1997) sampled several sites in the Gauley River watershed. Meadow River (the largest tributary to Gauley River within the park) was sampled near its mouth in 1997 for bed sediment and fish tissue contaminants. A site on Peters Creek (the second largest tributary within the park) just outside the park boundary served as a basic fixed site during 1997-98.

The West Virginia Division of Environmental Protection operates a monthly water quality station near the mouth of the Gauley River. In addition, West Virginia Division of Environmental Protection conducted benthic macroinvertebrate-based reconnaissance sampling in the Gauley River watershed in 1998 (Janice Smithson, West Virginia Division of Environmental Protection, personal communication 1998). This sampling used the U. S. Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) II (Plafkin *et al.* 1991). The West Virginia Division of Natural Resources, which conducts the U. S. Environmental Protection Agency's Environmental Monitoring and Assessment (EMAP) program sampling in West Virginia, sampled the Meadow River near its mouth in 1998.

The Meadow River basin is a large, complex system that includes West Virginia's second-largest wetlands complex at its headwaters (Little and Waldron 1996). Water-quality degrading land uses in the Meadow River basin include coal mining, improper disposal of human wastes, logging, and agriculture (West Virginia Department of Natural Resources 1989). The hydrologic nature of Meadow River changes substantially near where it enters Gauley River National Recreation Area. The stream changes from one of relatively low-gradient to one of extremely high-gradient stream as it enters a deep, narrow canyon for last 5 to 7 miles before its confluence with Gauley River.

Description of Recommended Project or Activity

Baseline inventory and monitoring of water quality and aquatic biological resources in the Gauley River National Recreation Area was identified as a high-priority water resource issue (National Park Service 1998). The proposed project has three main objectives designed to meet this need.

The first objective is to assess the state of knowledge, and evaluate the status, of water quality and aquatic ecological conditions in the Gauley River watershed within and adjacent to Gauley River National Recreation Area. Work designed to meet this objective will focus on compiling and analyzing existing data.

The second objective is to validate existing data while at the same time furthering the state of knowledge of present water quality and aquatic ecological conditions in the Gauley River watershed. This objective will be met by re-sampling many sites from prior studies to provide a first approximation of water quality and aquatic ecological trends.

The third objective is to design and evaluate a long term monitoring program for water quality and aquatic ecological conditions in Gauley River National Recreation Area. Meeting this objective will allow the National Park Service to more effectively manage activities and use within the park. This will also enable the National Park Service to better evaluate potential impacts of activities occurring outside park boundaries but within the Gauley River watershed.

In order to meet these three objectives, a three-step process will be employed. Each step is designed to meet one of the objectives.

Part 1 - Compile and Analyze Existing Data

The first step will be to identify, summarize, and interpret existing data describing water quality and aquatic biological resources of the Gauley River watershed. This effort will focus on the drainage area downstream from Summersville Dam, including the Meadow River watershed. In addition to the studies mentioned above, ongoing data collection efforts being conducted by other agencies and researchers will be identified and this information incorporated into the summary. Significant data gaps will also be identified.

Interpreting these disparate studies in an integrated manner will add value to each of them. This information will provide a sound basis for designing future monitoring and other trend studies, and will provide the National Park Service with a cogent background to evaluate changes in water quality and aquatic ecological conditions in the Gauley River watershed.

Part 2 - Assess Current Status and Trends

In an intensive, 1-year study, sites sampled in three earlier studies (water chemistry data used by Ehlke *et al.* 1982 and McAuley 1985, invertebrate data of U. S. Fish and Wildlife Service 1977, and fish data of Hocutt *et al.* 1979) will be re-sampled. This effort will provide a second "snapshot" of conditions in the Gauley River watershed. Comparison of this information with that gathered in Part 1 will provide a first estimate of trends within the watershed.

Three sites in or near Gauley River National Recreation Area which have U. S. Geological Survey-maintained stream gages (Gauley River below Summersville Dam, Gauley River above Belva, Meadow River near Mt. Lookout) will be sampled every two months to evaluate flow-weighted changes in water chemistry. These 3 sites represent, respectively, the upper and lower ends of the Gauley River, and the lower end of the Meadow River in Gauley River National Recreation Area. Two additional sites (Meadow River at Nallen and Peters Creek near Lockwood) will be sampled to describe water quality and aquatic ecological conditions of these tributaries before they enter Gauley River National Recreation Area. These sites were sampled 12 times over 2 years (1980-81 Water Years) for field parameters and concentrations of major ions, nutrients, indicator bacteria, and dissolved iron, manganese, and aluminum, as part of the Gauley River Basin Study.

Most of the constituents assessed during the Gauley River Basin Study remain relevant and of interest. Iron, manganese, and aluminum are of interest because elevated concentrations of these metals often indicate the effects of coal mining, particularly acid mine drainage. Coal mining remains an extensive land use in this watershed (West Virginia Department of Natural Resources 1989b). Historical data for iron, manganese, and aluminum at the concentrations that these metals were detected in this watershed are considered valid. Fecal coliform indicator bacteria are important to sample because pathogens from inadequately treated human wastes are the most important water-related human health threat in Gauley River National Recreation Area.

Fish and macroinvertebrate communities will be assessed at the above sites according to NAWQA methods (Meador *et al.* 1993, Cuffney *et al.* 1993). Macroinvertebrate sampling methods will include, but not necessarily be limited to, the NAWQA richest targeted habitat semi-quantitative protocol, and the qualitative multi-habitat protocol. The historical fish survey (Hocutt *et al.* 1979) was designed to collect representative qualitative samples to make a complete species list, rather than assess community productivity and health. Additional data will be collected to meet these latter objectives.

So that more direct comparisons can be made to the work of Hocutt *et al.* (1979), additional qualitative electrofishing is anticipated outside the established sampling reach.

This study will also include synoptic sampling. This will include re-sampling a selected subset of the U. S. Geological Survey chemistry synoptic sites, the U. S. Fish and Wildlife Service invertebrate sites, and Hocutt *et al.*'s fish survey sites. The methods used should be such that comparisons can be made with the original studies. However, additional effort or alternative methods may be used if deemed appropriate. The stream chemistry synoptic study will also assess indicator bacteria.

The discontinued U. S. Geological Survey stream gage at Peters Creek near Lockwood will be activated and continuous flow records collected there. This stream is the only small tributary (< 50 mi^2) in the vicinity of Gauley River National Recreation Area with a long-term (30 years) flow record. Flow information from this site will be useful for describing hydrologic conditions for other small streams in this area.

Attempts will be made to interest other agencies such (i.e. U. S. Fish and Wildlife Service, U. S. Forest Service, West Virginia Department of Natural Resources, West Virginia Department of Environmental Protection, etc.) in extending the scope of this study to the entire Gauley River watershed.

A report will be generated that evaluates the re-sampling, and discuss changes in land use, water quality, and stream ecology from the earlier studies. Copies of this report will be made available to other agencies, organizations, and individuals working or interested in the Gauley River watershed.

Part 3 - Develop Long Term Monitoring System for the Gauley River Watershed

Considering the information developed in Parts 1 and 2, a plan will be devised for long-term monitoring of the Gauley River watershed to meet National Park Service management objectives. Items to be considered for inclusion in this plan should include, stream flow, physical and chemical water quality, physical habitat, channel geomorphology, bacteria, seston, periphyton, benthic macroinvertebrates, and fishes. It is not necessary that all of these items be included in the final plan. The plan will include a sampling schedule (frequency and season), and an evaluation of the time and work force needed to accomplish the sampling and subsequent laboratory processing. It is anticipated that the National Park Service will assume full responsibility for executing the monitoring program, so consideration will be given to current staffing levels and laboratory capabilities, as well as time required for other commitments of National Park Service staff.

Because of ongoing extensive and intensive long-term monitoring in New River Gorge National River, the local National Park Service Aquatic Resources staff is experienced with a variety of monitoring methods. The long-term monitoring plan for the Gauley River watershed will emphasize methods with which the staff is familiar. Effort will be made to ensure that results of monitoring within the Gauley River watershed are comparable to results from ongoing monitoring programs conducted in New River Gorge National River.

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Proposed Budget

This budget is preliminary, and is based on figures generated by the U. S. Geological Survey. More detailed cost estimates will be developed at a later date.

	Budget	FTE
Year 1 (Part 1):	45.00	1.00
Year 2 (Part 2):	125.00	1.00
Year 3 (Part 3):	55.00	1.00
Total:	**225.00**	**3.00**

Evaluate the Long-Term Monitoring Program in New River Gorge National River

RMP Project Number: NERI-N-001.108
PMIS Number: 91436

Background

The National Park Service is charged with monitoring the ecological health of the New River within New River Gorge National River. Toward this goal, a comprehensive environmental monitoring program, or Long-Term Ecological Monitoring System (LTEMS), was developed. Since 1988 LTEMS has assessed seston, periphyton, and benthic macroinvertebrate and fish communities at several locations along the New River. Over this period of time several concerns have been noted with existing LTEMS protocols, particularly in the benthic macroinvertebrate component. The purpose of this proposal is to examine the existing LTEMS program, and to evaluate potential alternative methods and protocols that will alleviate these concerns.

The major problem with the existing LTEMS protocols is the time required for laboratory processing of macroinvertebrate samples. Under original protocols, complete sample processing (sorting and identification) took one or more years after samples are collected. This placed the park aquatic resources staff in a perpetual state of trying to catch up. This delayed data entry and analysis, which delayed processing of samples collected in successive years, and so on. The ultimate effect of this is a delay in the delivery of useful information to park management. If the full benefits of monitoring are to be realized, results must be interpreted promptly. Modified sample processing procedures can solve this problem.

In order to address the sample processing time, the park initiated a sub-sampling protocol. This has significantly reduced the backlog of unsorted samples, but these samples have not yet been identified. Also, the park has some earlier samples that were sorted from the entire sample and have not yet been identified. The park intends to sub-sample these samples prior to identification. These samples may prove useful in part of the study out-lined below.

Another reason to reexamine LTEMS is the development of new benthic biomonitoring methods since the New River Gorge program was conceived. Incorporation of these methods, especially when combined with modified sample processing, may greatly enhance the efficiency and credibility of the New River Gorge LTEMS data.

Another problem with existing LTEMS protocols involves the sampling of *Justicia* (water willow) habitat. Water willow is an emergent aquatic macrophyte that forms large beds in shallow areas of the New River. This is an important habitat for benthic macroinvertebrates and fishes. Additionally, *Justicia* beds are important in stabilizing gravel. The current use of the Ellis-Rutter Stream Sampler (formerly known as the Portable Invertebrate Box Sampler, or PIBS) to describe benthic communities in *Justicia* beds is not effective. *Justicia* stems significantly reduce flow, interfering with the operation of this sampler. Consequently, these samples must be collected from the lateral edges of *Justicia* beds to attain flowing water; thus only habitat margins are assessed. Also, the use of above-water biomass to measure *Justicia* "health" is highly questionable due to water-levels fluctuations.

The primary argument against incorporating new methods into LTEMS is to protect the data set's historical integrity. Long-term environmental monitoring programs are rare, and data sets as intensive as those for New River are even rarer for such large river ecosystems. Long-term monitoring requires either consistent methodology, or methodological changes which have precisely documented comparisons. This is necessary to provide interpretive continuity across the time span of the data set. Changing methods without detailing how those changes affect generated data severely limits the otherwise great value of long-term data, and makes comparisons of future data with data from the past difficult. This study will provide detailed comparisons between existing methods and those proposed for future use.

Results from early years of the LTEMS program have been summarized (Voshell and Orth 1995) and undergone rigorous statistical analyses (Smith and Marini 1998). Up-to-date analyses of fish data are currently underway. Now, before additional effort is expended on methods that may not be sustainable or yield useful results, is the logical time to evaluate existing procedures and determine whether any changes are desirable.

This project has several objectives. The first objective is to ensure that the LTEMS design timely provides useful data. The second objective is to ensure that LTEMS uses scientifically credible methods so that management decisions based on the data and analyses are sound and defensible. The third objective is to increase the information provided by LTEMS by strengthening weak areas. The fourth objective is to make the data more credible by the application of appropriate Quality Assurance/Quality Control procedures. The fifth objective is to protect the value of previously collected data if and when methods of collection or analysis change.

<u>Description of Recommended Project or Activity</u>

This proposal is divided into two phases. Phase I will address the problems of excessive time required to process collected macroinvertebrate samples. This work is divided into several units. One unit is Subsampling Effort Evaluation (SEE), and will evaluate the benefits of processing only a portion of each collected sample rather than all of it. Another unit is Taxonomic Effort Evaluation (TEE), and will evaluate the benefits of identifying collected organisms to various levels of taxonomic refinement. A third unit is Quality Assurance/Quality Control (QA/QC) that will be used to establish the credibility of collected data. Phase II will address the problem of *Justicia* habitat assessment, and also includes detailed macroinvertebrate surveys with species-level taxonomy.

Phase I

Phase I study involves comparisons between two sets of samples. Park staff will collect and process one set of LTEMS samples according to existing protocols. At the same time, another set of samples will be independently collected and processed using alternative methods. The data sets thus generated will be the basis for all comparisons recommended in this proposal. To prevent seasonal effects from confounding the results, the independent samples will be collected at the same time as those collected by the park. These samples will be collected at all LTEMS sampling locations.

At each LTEMS sampling site, samples will be collected from two of the three regularly sampled habitats (Cobble/Pebble Riffle and Rock Outcrop). These two distinct habitats support different communities, and are sampled using different gear with markedly different sample areas. The Ellis-Rutter Stream Sampler ($0.1m^2$) is used in the Cobble/Pebble Riffle habitat. The Rock Outcrop Community Sampler (ROCS; $0.01m^2$) is used on the Rock Outcrop habitat.

Subsampling Effort Evaluation (SEE)

Original LTEMS protocol required processing entire samples. Many of these samples take one or more weeks to sort. In 2001 the park began a sub-sampling program to shorten this sorting time and eliminate the backlog of unsorted samples. The sub-sampling program has proved effective in meeting its goals. Sample processing time has been reduced from days to hours. Procedural changes brought about by sub-sampling may affect the values and variances of metrics calculated by LTEMS. This evaluation is designed to compare the existing, and possible other, sub-sampling protocols with the original LTEMS protocols in terms of differences in metric score values, variances, and statistical power.

Laboratory

To evaluate the most effective level of sub-sampling effort, it is initially proposed to process two 100-organism-count portions and analyze them separately for each sample, using the design of Caton (1991). Since two 100-count portions will be removed, one will be randomly selected to represent the 100-count sub-sampling treatment. The 200-count treatment will be formed by combining data from the two 100-count sub-samples. Invertebrates present in each sub-sample portion will be identified to the lowest possible taxonomic level (usually genus). For the purpose of this analysis, midges (Diptera; Chironomidae) will be identified to family, just as is done for LTEMS. Park personnel will sort the samples and identify the organisms according to existing protocols.

A second evaluation will be made of the current sub-sampling protocol. This protocol involves taking 1/8 of a sample and counting this portion. Multiplying this result by 8 yields an estimate of the total number of organisms in the whole sample. In especially dense samples the 1/8 portion may be sub-sampled again to 1/64, and the results multiplied by 64. In sparser samples, ¼ or ½ of the sample may be counted, and the results multiplied by 4 or two, respectively. To evaluate this protocol, multiple sub-samples will be taken and counted from several whole samples, and the similarity of results from sub-samples within a given sample will be compared to each other.

Analysis

Results of different sub-sampling levels will be compared with those of the concurrently collected LTEMS samples using 10 to 15 biological metrics. These will include all the original metrics, as well as some more recently developed. The primary endpoint for this analysis will be a comparison of statistical power to assess statistical sensitivity of these alternative sub-sampling regimes. A MANOVA, or a two-way ANOVA with orthogonal contrasts, will be performed to describe differences among stations and sub-sampling level for each metric. Additionally, separate one-way ANOVAs with multiple comparisons will be run on the metric matrices for each sub-sampling level. The purpose of this analysis is to mimic the findings of park staff as if they had only performed one of the levels of sub-sampling. These results will illustrate the ability (or inability) of a given sub-sampling regime and level to accurately describe a sample, and the differences between samples among stations.

Assuming that completely processed samples describe the "true condition" at each station, sub-sampling methods should be able to detect differences among stations if they are to be useful measures. These analyses will be run for each of the 10-15 metrics, each sub-sampling level, and each habitat (60-90 ANOVA analyses, 60-90 Power Analyses, and several MANOVA analyses) and will be summarized graphically and interpreted in a report. Depending on the actual nature of the data, slightly different statistical methodology may be necessary.

These analyses may initially seem redundant. However, conducting both ANOVA comparisons of results of each level of sub-sampling and a power analysis addresses two key concerns: the environmental and the statistical sensitivity of each level of sub-sampling. That is, (1) the sensitivity of metrics under different levels of sub-sampling to describe "known" differences among stations and (2) the statistical ability to detect changes.

Sample processing time will be recorded and evaluated. It is anticipated that mean processing time and variance for sub-samples will be markedly less than for whole samples. This will allow resource managers to weigh the costs and benefits of a sub-sampling program. A detailed report containing all of the results, analyses, and recommendations of this component will be provided.

Taxonomic Effort Evaluation (TEE)

The level of taxonomy applied to benthic macroinvertebrate surveys has a significant effect on calculated metrics. The most directly affected metrics are those that describe the number of taxa, such as taxa richness and EPT index (number of Ephemeroptera, Plecoptera and Trichoptera; organisms indicative of clean water). Many other metrics include taxa richness in their calculation, and also may be affected. The current LTEMS protocol currently identifies all taxa to the lowest practical taxon, usually genus. However, Chironomidae are only identified to family due to their small size and the time and effort required to identify them to lower levels of taxonomy. Chironomids, abundant in the New River, are closely related to black flies (Diptera: Simuliidae), which are the target of an intensive, state-run spraying program involving the bacterial insecticide *Bacillus thuringensis israeliensis* (*Bti*). Due to dietary overlap, chironomids are the non-target organisms most likely to be affected by the spraying program, yet they are not adequately accounted for by current LTEMS protocols.

Sample processing time for LTEMS currently prohibits more refined chironomid taxonomy. Sub-sampling procedures may save enough time to allow greater refinement. Moreover, such refinement may be required to detect impacts of *Bti* spraying.

Laboratory

One of the sub-sampled data sets discussed above (100-count or 200-count) from both habitats will be selected and used to compare the effects of different levels of chironomid taxonomy on metric scores, statistical power, and processing time. It is preferable to conduct this analysis on the 200-count data set, but it may be necessary to sub-sample the larvae to keep the project on schedule and within budget. Chironomids will be removed from the sub-samples and mounted in Euparal® mounting medium prior to identification using light microscopy. All midges will be identified to genus, if age and condition makes this possible.

Analysis

Analytical methods used for TEE will be similar to those used for SEE. That is, about 10-15 metrics will be used to describe environmental and statistical sensitivity of different levels of taxonomy. These metrics will undergo power analysis, MANOVA (or two way ANOVA with orthogonal contrasts), and one-way ANOVA. The overall design of these tests will be 1 level of sub-sampling, 4 stations, and three levels of chironomid taxonomy (family, sub-family, genus) with analyses conducted for both cobble/pebble and rock outcrop habitats. As with SEE, this component includes about 60-90 power analyses, 60-90 one-way ANOVAs, and several MANOVAs (or 60-90 two-way ANOVAs). Additionally, sample-processing time will be tracked, and means and standard deviations of these measures reported. A detailed report of all analyses, results and recommendations will be provided as a deliverable for this component.

Quality Assurance / Quality Control Evaluation (QA/QC)

Other than proofing data entry files, the current LTEMS design has no built in QA/QC to insure program integrity. Steps should be taken to prevent the quality of the data from coming into question. Sorting efficiency will be described as a percent efficiency for sub-sampled and non-sub-sampled portions.

Laboratory records will be subject to an independent QA/QC review using established standards. Results of this review will be presented in the final report. Detailed accounts of recommended standard operating procedures (SOPs) will be included to allow park staff to carry on the research without compromising consistent methodology. Since the park has had the same sorting personnel for several years, this is an especially valuable assessment, and will lend credibility to prior year's data.

Schedule and Deliverables

Phase I begins with field sample collection in August of Year 1, and continues throughout the possessing of these samples. The timing of the Phase I deliverables is largely dependant on the amount of time it takes park staff to complete laboratory processing of whole samples, and to provide the associated data matrix. However, if we assume that the park can provide the data by the following May the analyses should be completed by October of Year 2. Deliverables include a comprehensive report detailing the results of the SEE, TEE and QA/QC components of the study, as well as periodic progress reports. Detailed SOP's will also be provided.

Phase II

Phase II includes a reevaluation of SEE and TEE to account for temporal variation. These analyses will be conducted similarly to those for Phase I, but may be slightly modified depending on the results of Phase I. Additionally, Phase II expands the scope of LTEMS by providing an improved qualitative macroinvertebrate survey and a detailed assessment of *Justicia* habitat.

Qualitative Macroinvertebrate Survey

As many taxa as is possible will be collected in one day from each station. As many as possible of these taxa will be identified to species. This will provide a comprehensive taxa list for each station. Recognized experts for appropriate taxa will be contracted to confirm identifications. Also, whenever possible, adults will be collected, or reared from larvae. This will associate juveniles that are not yet identified to species with adults that can be identified to species. Findings to be reported include the taxonomic composition of each station, a description of key habitats and the species found in them, and differences between stations.

Justicia Habitat Assessment

Justicia habitat will be quantitatively assessed, as will its value as a habitat for benthic macroinvertebrates. Sampling will be conducted using a modified coring device. The results will be compared to those from LTEMS methods. Additionally, *Justicia* beds will be mapped using Global Positioning System (GPS) technology. The report generated by this work will also include recommendations on appropriate steps for future monitoring of this habitat.

QA/QC

The Phase II QA/QC will only be conducted on samples processed by the contractor. The QA SOPs developed will be provided to the park to perform sorting efficiency checks in-house for Phase II. This results in a significant reduction in the cost for this phase, when compared with Phase I (see Proposed Budget, below).

Schedule and Deliverables

Phase II begins with field sample collection in August of Year 2, and continues through the processing of these samples. The timing of Phase II deliverables is largely dependant on the amount of time it takes park staff to complete laboratory processing of the whole samples, and to provide the associated data matrix. However, assuming that the park can provide the data by the following May, the analyses should be completed by the next October. Deliverables include a comprehensive report detailing the results of SEE, TEE, qualitative macroinvertebrate survey, *Justicia* habitat assessment (including GPS data) and QA/QC components of the study as well as periodic progress reports.

Literature Cited

Caton, L. 1991. Improved sampling methods for the EPA "Rapid Bioassessment" benthic protocols. North American Benthological Society Bulletin 8(3):317-319.

Smith, E. and M. Marini. 1998. Analysis of long term ecological monitoring of the New River Gorge National River. Technical report in partial fulfillment of cooperative agreement CA4000-3-2013. Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg.

Voshell J. and D. Orth. 1995. Ecological monitoring in the New River Gorge National River: analysis of environmental impacts from the black fly pest management program. Draft Final Report. Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg.

Proposed Budget

Year 1:	$109,000
Year 2:	$188,000
Total:	**$297,000**

This budget is preliminary based on figures provided by the U. S. Geological Survey. Detailed cost estimates will be developed later.

Historical Fisheries Data Mining

RMP Project Number: NERI-N-001.117
PMIS Number: 91438

Background

The New River system, including the Bluestone and Gauley rivers, has only 46 native fishes and the lowest ratio of native fishes to drainage area of any river system in the eastern United States (Jenkins and Burkhead 1994). The species depauperate New River fish fauna has been extremely susceptible to invasion. It has the largest number (42) and proportion (47%) of introduced freshwater species of all major eastern and central North American river systems.

Very few spatially extensive surveys of fish species in the New, Bluestone, and Gauley River systems exist in the published literature (Cope 1868, Addair 1944, Stauffer *et al.* 1980, Hocutt *et al.* 1979). Other studies have investigated particular aspects of the ecology of one or a few species, but these reports contain little information of the other species that exist with the species being studied.

The West Virginia Department of Natural Resources has conducted about 3,000 fish surveys since the 1960's. Prior to this, non-game fish were not identified to species (Tom Bassista, West Virginia Department of Natural Resources, personal communication 1999). The West Virginia Department of Natural Resources also receives collection permit reports from academic and other-agency researchers who survey fishes within the state. Of the 3,000 fish surveys, many included only game species, only biomass (no counts), or only certain habitats (e.g. in pools but not in riffles). It is not known how many of these fish surveys were made in streams of interest to the National Park Service.

These data have not been published and currently exist mostly as paper files. The West Virginia Department of Natural Resources is preparing a database of the fish surveys that includes location, stream name, investigator, and some other ancillary data. They are populating this database with fields describing the reliability and collection method of the survey. Funding is being sought to complete data entry of those surveys deemed reliable. If these data were available in a readily accessible, usable format, they should prove useful in determining trends in the composition of the New River fish assemblage.

Description of Recommended Project or Activity

The objective of this action is to develop a database of historical fishery information for the New, Bluestone, and Gauley rivers. Sources of existing historical data on fish communities will be determined by contacting the West Virginia Department of Wildlife Resources, and by universities that may have studied fishes in the vicinity of the three parks. The West Virginia Department of Natural Resources paper-file data, along with other ancillary data, will be entered into computer files.

Thirty reliable surveys from the Bluestone, New, and Gauley river basins will be selected. First priority will be given to surveys done inside the present boundary of the parks, second priority to upstream reaches of tributaries not separated from the parks by significant barriers to fish movement (dams), and third priority given to other streams in the New River watershed. All files will be geographically referenced, so that they will be compatible with Geographic Information System software. Data entry and processing will include a complete check of all data entered, and final files will include appropriate metadata.

Computer files prepared by the National Park Service will be shared with the state, and have a format consistent with the West Virginia Department of Natural Resources format.

Literature Cited

Addair, J. 1944. The fishes of the Kanawha river system in West Virginia and some factors which influence their distribution. PhD dissertation, Ohio State University, Columbus.

Cope, E. 1868. On the distribution of fresh-water fishes in the Allegheny region of Southwestern Virginia. Journal of Academy of Natural Sciences of Philadelphia, Series 2, 6, Part 3, Article 5, pp. 204-247.

Hocutt, C., R. Denoncourt and J. Stauffer, Jr. 1979. Fishes of the Gauley River, West Virginia. Brimleyana 1:47-80.

Jenkins, R. and N. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD. 1079 p.

Stauffer, J., Jr., C. Hocutt and S. Markham. 1980. Final report, aquatic biological survey of the New River, Virginia and West Virginia. Appalachian Environmental Laboratory, University of Maryland, Frostburg State College Campus, Frostburg, Md. [unpublished report on file with the U. S. Fish and Wildlife Service, Elkins, WV]. 19 p.

Proposed Budget

Initial estimates are that the contract/interagency agreement for this work will cost $5,000-10,000. The project should take one year to complete.

Inventory Fishes of Gauley River National Recreation Area

RMP Project Number: NERI-N-001.118
PMIS Number: 89373

Background

A main objective for the Inventory and Monitoring (I&M) Program of the National Park Service calls for documentation of at least 90% of the species of fishes that occur in each park. In a previous I&M Program meeting it was decided that additional inventories are needed in National Park Service lands along the New, Gauley, and Bluestone rivers to achieve this 90% objective. Distributional data of fishes in the New, Gauley, and Bluestone rivers are available from Stauffer *et al.* (1995), West Virginia Department of Natural Resources (Dan Cincotta, pers. comm.), and museum records (such as Cornell, University of Michigan, and Smithsonian). Previous fish surveys within park boundaries probably do not achieve the 90% objective. For example, Stauffer *et al.* (1995) includes less than 10 collection sites within the Gauley River National Recreation Area boundary.

Description of Recommended Project or Activity

It is proposed to conduct an updated inventory of the fishes in Gauley River National Recreation Area to achieve this 90% objective, and provide this new distributional data in a single database for import into a GIS (ARC/VIEW). All distributional data will be cross checked for accuracy and geo-referenced to the National Hydrography Dataset stream locations. Data entry will follow Geographic Data Committee standards, including the FGDC Content Standard for Digital Geospatial Metadata.

Distributional data will be obtained by sampling the main stem and tributaries of the Gauley River within park boundaries. Fish sampling will be done primarily by backpack electrofishing and will follow guidelines of the EPA Rapid Biological Assessment protocol for wadeable streams. Other collection methods may be required for larger main stem sites, such as parallel wire or boat-mounted electrofishing techniques. Samples will be collected at 90 locations that represent the main stem and tributaries (including Meadow River) within park boundaries. The location of sample sites will be determined in consultation with park staff and the West Virginia Department of Natural Resources.

The end product of this work will be a distributional database of fishes within the Gauley River National Recreation Area. The database will be provided in a GIS compatible format, and will contain new distributional data with associated metadata.

Literature Cited

Stauffer, J., J.Boltz and L.White. 1995. The fishes of West Virginia. Philadelphia Academy of Natural Sciences.

Proposed Budget

1. Graduate Research Assistant (M.S. student stipend for 1 year)	$10,000
2. Field Assistants (2 persons for 4 weeks at $8/hour)	$ 3,840
3. Fringe benefits (7.9% of 2.)	$ 303
Sub-total personnel costs	$14,143
4. Equipment and supplies (nets, seines, waders, etc.)	$ 2,900
5. Per diem (30 field days at $30/d/person)	$ 2,700
6. Lodging (30 field days at $80 per day)	$ 2,400
7. Vehicle rental (4 weeks at $400/week	$ 1,600
8. Vehicle fuel	$ 1,500
Sub-total travel costs	$ 8,200
Total	**$25,243**

Inventory Fishes of Bluestone National Scenic River

RMP Project Number: NERI-N-001.119
PMIS Number: 89349

Background

A main objective for the Inventory and Monitoring (I&M) Program of the National Park Service calls for documentation of at least 90% of the species of fishes that occur in each park. In a previous I&M Program meeting it was decided that additional inventories are needed in National Park Service lands along the New, Gauley, and Bluestone rivers to achieve this 90% objective. Distributional data of fishes in the New, Gauley, and Bluestone rivers are available from Stauffer *et al.* (1995), West Virginia Department of Natural Resources (Dan Cincotta, personal communication 2000), and museum records (such as Cornell, University of Michigan, and Smithsonian).

The fish fauna of the Bluestone River is the least understood of the three parks (Dan Cincotta, West Virginia Department of Natural Resources, personal communication 2000). Previous fish surveys within park boundaries of the Bluestone National Scenic River probably do not achieve the 90% objective. For example, Stauffer *et al.* (1995) includes less than 10 collection sites within the boundaries of the Bluestone National Scenic River.

Description of Recommended Project or Activity

It is proposed to conduct an additional inventory of the Bluestone National Scenic River to achieve this 90% objective, and provide this new distributional data in a single database for import into a GIS (ARC/VIEW). All distributional data will be cross checked for accuracy and geo-referenced to the National Hydrography Dataset stream locations. Data entry will follow Geographic Data Committee standards, including the FGDC Content Standard for Digital Geospatial Metadata.

Distributional data will be obtained by sampling the main stem and tributaries of the Bluestone National Scenic River within park boundaries. Fish sampling will be done primarily by backpack electrofishing and will follow guidelines of the EPA Rapid Biological Assessment protocol for wadeable streams. Other collection methods may be required for larger main stem sites, such as parallel wire or boat-mounted electrofishing techniques. It is proposed to collect at 90 locations that represent the main stem and tributaries within park boundaries. The location of sample sites and design will be determined in consultation with National Park Service and West Virginia Department of Natural Resources staff.

The end product of this work will be a distributional database of fishes within Bluestone National Scenic River. This database will be provided in a GIS compatible format, and will contain distributional data and metadata.

Literature Cited

Stauffer, J.R., J.M. Boltz and L.R. White. 1995. The fishes of West Virginia. Philadelphia Academy of Natural Sciences.

Proposed Budget

1. Graduate Research Assistant (M.S. student stipend for 1 year)	$10,000
2. Field Assistants (2 persons for 4 weeks at $8/hour)	$ 3,840
3. Fringe benefits (7.9% of 2.)	$ 303
Sub-total personnel costs	$14,143
4. Equipment and supplies (nets, seines, waders, etc.)	$ 2,900
5. Per diem (30 field days at $30/d/person)	$ 2,700
6. Lodging (30 field days at $80 per day)	$ 2,400
7. Vehicle rental (4 weeks at $400/week	$ 1,600
8. Vehicle fuel	$ 1,500
Sub-total travel costs	$ 8,200
Total	**$25,243**

Note: If this project is performed in concert with **Inventory Fishes of Gauley River National Recreation Area** (PMIS #89373), considerable savings may be realized.

Monitor Status and Distribution of Fishes in New River Gorge National River

RMP Project Number: NERI-N-001.120
PMIS Number: 91439

Background

The introduction to the New River and its tributaries of new species of fish, particularly as bait-bucket introductions by fishermen, continues at the present (Cincotta *et al.* 1999). Other non-native fish species are expanding their ranges in the New River system, possibly at the expense of native species. Examples include telescope shiner, spottail shiner, margined madtom, least brook lamprey, and variegate darter. Jenkins and Burkhead (1994) have suggested that the once depauperate New River system, in which 42 of 89 known fish species are introduced, can be thought of as a laboratory in interactions of introduced fish. Cincotta *et al.* (1999) caution that monitoring the progress of this unplanned experiment is necessary to understand its results, and that information lost now cannot be recovered later.

Current fish-community data are available for 5 sites on the New River main channel, from the park's Long Term Ecological Monitoring System (LTEMS) program. The U. S. Geological National Water Quality Assessment (NAWQA) program for the Kanawha-New River watershed also collected a fish community sample at one of the LTEMS sites, and another sample from Peters Creek near Lockwood, a Gauley River tributary. With the possible exception of a few streams where trout are stocked, little other fish community data have been collected in these streams since 1979-84, and no quantitative surveys have ever been done of some tributaries (Dan Cincotta, West Virginia Department of Natural Resources, personal communication 2000).

Description of Recommended Project or Activity

Sixty sites will be selected. Most sites will be inside park boundaries, but on larger streams it may be advisable to include some sites outside of the boundary. This will be useful because road access to these streams is often a great deal easier upstream of the park boundary. Cryptic fish introductions more common at such locations.

In July-August, fish communities will be sampled by an appropriate electrofishing method for the size of the stream, following modified NAWQA protocols (Meador *et al.* 1993). After a representative reach has been sampled, additional qualitative electrofishing and selective netting will be done at sites where best professional judgement suggests that additional species may be present in habitat types not contained in the main sample reach. Fish will be identified to species, weighed and measured, and external anomalies will be noted. For quality control, fish voucher specimens and problematic individuals will be preserved. A recognized expert in local fishes will confirm identifications. Collections from most sites will be made using a backpack electrofisher. On the average, for sites sampled by backpack electrofishing, two collections per day will be made, using a crew of three persons. Sites on the New River will require use of a towed barge and a crew of six persons. Travel between sites and equipment cleaning and maintenance will take average one hour. Laboratory processing of preserved specimens will require an average of 6 staff-hours per collection. Data entry and management will also take an average of 6 staff-hours per collection. This combines for an overall average of 30 staff-hours per collection. Data manipulation and interpretation and report writing are estimated to take 400 hours.

If sufficient time is available, the service provider will evaluate the fish data relative to water quality. This will be accomplished by use of an appropriate Index of Biotic Integrity (IBI). Such an index suitable for West Virginia is currently being developed by the West Virginia Department of Natural Resources and the U. S. Environmental Protection Agency (Tom Bassista, West Virginia Department of Natural Resources Natural Heritage Program, personal communication 2000). Because fish integrate exposure to stresses through time, this assessment will complement ongoing microbiological and chemical water sampling conducted by New River Gorge National River.

Data will be published in a report format to be agreed upon by the National Park Service and the service provider. This report will include a GIS-compatible map of fish species ranges in the study area.

Literature Cited

Cincotta, D., D. Chambers and T. Messinger. 1999. Recent changes in the distribution of fish species in the New River basin in West Virginia and Virginia. Pages 98-106 *In* Proceedings of the New River Symposium, Boone, N.C., April 16, 1999. National Park Service, Glen Jean, WV, 123 pp.

Jenkins, R. and N. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD, 1079 pp.

Meador, M., T. Cuffney and M. Gurtz. 1993. Methods for sampling fish communities as part of the National Water-Quality Assessment Program. U. S. Geological Survey Open-File Report 93-104, 40 pp.

Proposed Budget

It is estimated that this project will take one year to complete and will cost $50,000. More detailed cost estimates will be developed later.

Determine Impacts of Two Fishery Management Methods on Stream Ecosystems

RMP Project Number: NERI-N-001.121
PMIS Number: 53013

Background

Enabling legislation for New River Gorge National River allows the West Virginia Division of Natural Resources (DNR) to manage fisheries within park boundaries. In streams tributary to the New River, DNR accomplishes this primarily by stocking trout, and establishing differential-take regulations. Glade Creek has long been stocked by DNR, primarily with brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout. Most of these stockings involved excess brood-stock fish planted in the upper reaches of Glade Creek within the park. Thus this fishery has been managed on a put-and-take basis. Some stockings involved smaller fish, in attempts to establish a self-reproducing population. Some of these smaller fish, particularly brown trout, apparently have grown to adulthood and successfully spawned in lower Glade Creek. Two years ago DNR designated lower Glade Creek as a catch-and-release section.

A considerable amount of research has investigated the impacts of different regulations on target species (e.g. Clark *et al*. 1981). Little research has focused on the impacts of different angling regulations on non-target fish. There is also scant information on the impacts of these regulations to non-fish aquatic resources. Ward (1974) noted a slightly higher invertebrate density in a catch-and-release section versus a size-limit section of the South Platte River in Colorado. This study focused on another issue, and thus the results are not conclusive. The proposed project is designed to provide insight into both of these deficiencies.

Description of Recommended Project or Activity

The primary objective is to describe the impacts of different management strategies on two adjacent stretches of the same stream. The upper section is managed as a put-and-take fishery, while the lower section is managed on a catch-and-release basis.

Preliminary work will include habitat mapping of Glade Creek from its mouth to the mouth of Pinch Creek (upstream boundary of the park). Based upon the mapping, representative study reaches will be established in each of the two management reaches. All sampling will occur in those reaches.

Sampling will be conducted on a quarterly basis for one year. For each quarter, both sections will be sampled within the same week (two sampling events). Certain measurements will be taken on each sampling event. These include discharge, nutrients (total Kjeldahl nitrogen, ortho phosphate), and basic water quality (pH, conductivity, alkalinity, turbidity, and dissolved oxygen). A Hydrolab Datasonde will be deployed continuously from the footbridge that marks the boundary between the two sections. Temperature will be monitored continuously through the deployment of data loggers such as the HOBO or StowAway. Biota will be sampled and analyzed by standard methods. Protocols developed by the U. S. Geological Survey National Water Quality Assessment (NAWQA) program will be used to the greatest extent possible to validate potential comparisons with other surveys.

Fish will be sampled by two-pass electrofishing over a 200-meter length of each study reach. Fish will be identified, measured, and weighed in the field. Scale samples may be taken for possible later analysis. Stomach samples of large salmonids may be taken by gastric elutriation for potential later analysis. Sampling mortality will be noted, and all fish will be returned to the stream. Various community metrics will be calculated and evaluated to note differences in populations and communities between the two sections.

Five Ellis-Rutter Stream Sampler (formerly known as the Portable Invertebrate Box Sampler or PIBS) samples will be collected for each event. Invertebrates collected will be preserved in the field and returned to the laboratory for sorting and identification. Standard metrics will be calculated to note differences in populations and communities between the two sections. Samples will be retained for possible future analyses.

Eight periphyton samples will be collected per sampling event using bar-clamp samplers. Biomass and chlorophyll *a* will be analyzed in the laboratory, and used to note differences between sections.

Standard non-parametric statistical methods will be used to evaluate the magnitude of differences between each section on a given sampling date. Comparisons over time may be made within each section, and evaluated heuristically.

<u>Literature Cited</u>

Clark, R., Jr., G. Alexander and H. Gowing. 1981. A history and evaluation of regulations for brook trout and brown trout in Michigan. North American Journal of Fisheries Management 1: 1-14.

Ward, J. 1974. A temperature-stressed stream ecosystem below a hypolimnial release mountain reservoir. Archiv fur Hydrobiologie 74: 247-275.

<u>Proposed Budget</u>

Field mapping; 2 GS 5-5 Technicians, 80 Hours @ $18.39/hour	$1,471.20
Map production; 2 GS 5-5 Technicians, 80 Hours @ $18.39/hour	$1,471.20
Vehicle rental GSA class G61 Jeep Cherokee, two months @ $287.50/month	$557.00
Vehicle mileage GSA mileage rate for above vehicle, 2000 Miles @ $0.16/mile	$320.00
Field sampling; GS 11-5 Biologist, 8 hours for each of 16 events = 128 Hours @ $33.72/hour	$4,316.16
Field sampling; 2 GS 5-5 Technicians, 8 hours each per 16 sampling events = 256 Hours @ $18.39/hour	$4,707.84

Mapping oversight; GS 11-5 Biologist, 40 Hours @ $33.72/hour	$1,348.80
Continuous (HydroLab MiniSonde)	$5,775.00
Hobo temperature logger	$314.00
Installation materials for above	$200.00
Installation; WG 10 to install MiniSonde and temperature logger 40 Hours @ $24.80/hour	$992.00
Miscellaneous supplies (chemicals, disposables, sample bags and jars, etc.)	$1,000.00
Report preparation; GS 11-5 Biologist, 120 Hours @ $33.72/hour	$4,046.40
Statistical software to perform statistical data analysis	$1.200.00
Data analysis; GS 11-5 Biologist, 80 Hours @ $33.72/hour	$2,697.60
Data entry; GS 5-5 Technician, 80 Hours @ $18.39/hour	$1,471.20
Sample QA/QC; GS 11-5 Biologist, 40 Hours @ $33.72/hour	$1,348.80
Invertebrate sample processing; GS 5-5 Technicians, 40 (2x5x4) samples at 8 hours/sample = 320 Hours @ $18.39/hour	$5,884.80
TOTAL	**$39,122.00**

Determine Diets of Exotic Trout in New River Gorge Tributary Streams

RMP Project Number: NERI-N-001.122
PMIS Number: 53165

Background

The enabling legislation for New River Gorge National River permits the West Virginia Division of Natural Resources (DNR) to manage fisheries within the park. One of DNR's main tools in this regard is to stock trout, mostly exotic brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*), in many streams tributary to the New River. This is supposed to occur in consultation with the National Park Service. However, our ability to function in this consulting role is hampered by a lack of knowledge regarding the impacts of stocked trout on native fish communities. Since trout feed mainly on fish and aquatic invertebrates, knowing the preferred prey items is crucial to understanding the impacts of these exotics on native communities. Completion of this project will provide this information.

Two types of trout fisheries exist in New River Gorge National River. A put-and-take fishery exists where DNR plants excess brood stock of catchable size. Dunloup Creek and the upper reaches of Glade Creek are examples of streams under this fisheries management regime. Other streams are managed on a catch-and-release basis. In many cases such streams were originally stocked with fingerlings that eventually matured and reproduced, giving rise to a "wild" trout fishery. The lower section of Glade Creek is an example of this type of management. Buffalo Creek is also managed on a catch-and-release basis, with the additional stipulation that angling be by fly-fishing only.

Because two types of trout fisheries exist in New River Gorge streams, it is important to note the different impacts of these management strategies on stream ecosystems. Fish in "wild" trout streams exist year-round. Their continual presence has the potential to significantly alter stream ecosystems on a long-term basis. Fish stocked as part of a put-and-take fishery usually do not survive long. Typically, anglers catch them within two days of planting, although a few do survive for several weeks. Because of their short time in the stream, these fish are not though to have a great impact on native communities. However, because of their large relative size, the potential does exist for put-and-take planted fish to exert considerable predatory influence on stream ecosystem structure. It is important to document whether this impact occurs.

The objective of the proposed activity is to determine the direct impacts of exotic fishes on native fish communities and stream ecosystems of the central Appalachians by investigating diets of the exotic fishes. This will be accomplished by obtaining stomach samples from trout in three streams.

Description of Recommended Project or Activity

Intact stomachs will be obtained from angler-caught fish in Dunloup Creek and the put-and-take section of Glade Creek. Fish size and weight and stomach weight will be noted for these samples. The stomachs will be preserved in the field and returned to the lab for dissection and identification of the contents.

Dunloup Creek and the put-and-take section of Glade Creek will also be sampled by electrofishing, as will Buffalo Creek and the catch-and-release section of Glade Creek. Trout collected will have their stomachs sampled by gastric elutriation in the field. These fish will be returned to the stream after being weighed and measured. Stomach contents will be preserved in the field and returned to the laboratory for identification.

Stomach contents will be weighed and identified to the lowest possible taxonomic level. Appropriate statistical tests will be applied to describe the significance of the results. Whole stream impact of predation by stocked fish will be evaluated by separately determining the trout population of each stream section, and extrapolating the appropriate diet results to that population. Comparison of the two sampling methods for Dunloup Creek and the put-and-take section of Glade Creek will be made to further evaluate the results from Buffalo Creek and the catch-and-release section of Glade Creek. Final results will be submitted for publication in an appropriate peer-reviewed journal.

Proposed Budget

Base on 1999 figures, the preliminary estimate for the cost of this project is $27,000. More detailed cost estimates will be developed at a later date.

Evaluate Impacts of Exotic Trout on New River Gorge National River Tributary Ecosystems

RMP Project Number: NERI-N-001.123
PMIS Number: 52606

Background

Early reports (Cope 1868) do not indicate that brook trout (*Salvelinus fontinalis*) inhabited streams tributary to New River Gorge National River. Possible reasons for this exclusion include biogeographic isolation (Jenkins and Burkhead 1994, Stauffer *et al*. 1995) and temperature (MacCrimmon and Campbell 1969). The West Virginia Division of Natural Resources (DNR) stocks mostly brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout in some of these streams. This stocking usually supports a put-and-take fishery, with only a few trout populations remaining viable year-round. The impacts of these exotics on native stream ecosystems are largely unknown, primarily because fish faunas in small streams of this region have received little scientific attention (exceptions include Chipps *et al.* 1994 and Leftwich *et al.* 1996).

Scattered literature (Crossman 1991) indicates introduced predatory fishes, like trout, probably alter fish and invertebrate community structure in streams (Garman and Nielsen 1982, Allan 1983). Introduced game fish have been implicated in the decline and extinction of native fish populations (Miller *et al*. 1989, Moyle and Williams 1990). Benthic algal communities (periphyton) may be indirectly influenced by predator-induced depression of algivorous fish (Power and Matthews 1983, Stewart 1987) and invertebrates (Feminella and Hawkins 1995, Bourassa and Cattaneo 1998).

Enabling legislation for New River Gorge National River permits DNR to stock trout. This is supposed to occur in consultation with the National Park Service. Our ability to consult effectively is hampered by a lack of knowledge about native fish communities, and the impacts of exotic salmonids on area streams. Completion of this project will go a long way towards fulfilling these needs.

Description of Recommended Project or Activity

The general objective is to determine differences in stream ecosystems based on the presence or absence of exotic trout ("treatment"). Specific objectives include noting treatment differences in fish, invertebrate, and periphyton community structure. Ancillary objectives are to note differences in trophic structure and provide a baseline inventory of aquatic biota of New River tributaries.

This study uses a four stream comparative design. Two streams (Buffalo, Dunloup Creeks) are stocked with trout and two (Arbuckle, and Slater creeks) are not stocked. A stream habitat survey will include gradient determination and habitat mapping. Based on this information, a representative 500-meter study reach will be selected for each stream.

Each stream will be sampled quarterly for one year. Fish, invertebrate, and periphyton communities will be sampled and analyzed by standard methods (2-pass electrofishing, square-footprint stream sampler, bar-clamp samplers). Basic water quality (pH, EC, etc.), nutrients (TKN, orthophosphate), and discharge data will be collected. Temperature will be monitored continuously. Protocols developed by the U. S. Geological Survey National Water Quality Assessment (NAWQA) program will be used to the extent possible.

Fish collected will be identified, weighed, and measured in the field, and returned to the stream. Sampling mortality will be noted. Invertebrates will be sampled in cobble-gravel habitat using an Ellis-Rutter Stream Sampler (formerly the Portable Invertebrate Box Sampler, or PIBS). Periphyton will be sampled from large cobbles using bar-clamp samplers. Five samples of each type will be collected on each sampling date. Samples will be preserved in the field and returned to the NERI Aquatic Biology Laboratory for identification and enumeration.

Community composition will be determined using standard metrics. Non-parametric statistics will evaluate the significance of observed differences. Results will be submitted for publication in an appropriate peer reviewed journal.

<u>Literature Cited</u>

Allan, J. 1983. Predator-prey relationships in streams. Pages 191-229 *in* J. R. Barnes and G. W. Minshall (eds.). Stream ecology: application and testing of general ecological theory. Plenum Press, New York. 399 pp.

Bourassa, N. and A. Cattaneo. 1998. Control of periphyton biomass in Laurentian streams (Quebec). Journal of the North American Benthological Society 17: 420-429.

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Crossman, E. 1991. Introduced freshwater fishes: a review of the North American perspecctive with emphasis on Canada. Canadian Journal of Fisheries and Aquatic Sciences 48(supplement): 46-57.

Feminella, J. and C. Hawkins. 1995. Interactions between stream herbivores and periphyton: a quantitative analysis of past experiments. Journal of the North American Benthological Society 14: 465-509.

Garman, G. and L. Nielsen. 1982. Piscivory by stocked brown trout (*Salmo trutta*) and its impact on the nongame fish community of Bottom Creek, Virginia. Canadian Journal of Fisheries and Aquatic Sciences 39:862-869.

Jenkins, R. and N. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD. 1079pp.

Leftwich, K., C. Dolloff, M. Underwood and M. Hudy. 1996. The candy darter (*Etheostoma osburni*) in Stony Creek, George Washington National Forest, Virginia: trout predation, distribution, and habitat associations. United States Department of Agriculture, Forest Service, Center for Aquatic Technology Transfer, Virginia Polytechnic Institute and State University, Blacksburg, VA. 15 pp.

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Miller, R., J. Williams and J. Williams. 1989. Extinctions of North American fishes during the last century. Fisheries 14: 22-38.

Moyle, P. and J. Williams. 1990. Biodiversity loss in the temperate zone: decline of the native fish fauna of California. Conservation Biology 4: 275-284.

Power, M. and W. Matthews. 1983. Algae-grazing minnows (*Campostoma anomalum*), piscivorous bass (*Micropterus* spp.), and the distribution of attached algae in a small prairie-margin stream. Oecologia 60: 328-332.

Stauffer, J., Jr., J. Boltz and L. White. 1995. The fishes of West Virginia. Academy of Natural Sciences of Philadelphia. 389 pp.

Stewart, A. 1987. Responses of stream algae to grazing minnows and nutrients: a field test for interactions. Oecologia 72: 1-7.

<u>Proposed Budget</u>

Based on 1999 figures, preliminary estimates are that this project will cost $45,000. More detailed cost estimates will be developed at a later date.

Inventory Biological Resources of New River Tributaries

RMP Project #: NERI-N-001.107
PMIS #: 60852

Background

Over a dozen major streams, and many minor ones, are tributary to New River within New River Gorge National River. The total length of these streams, within the park, is greater than the length of the New River within the park. Because of their smaller size, tributary streams are more intimately associated with their watersheds than are larger rivers. Thus they are more affected by activities occurring on the land surface, and from pollution by both point and non-point sources. Their small size also makes them easier to manage, and offers the National Park Service the greatest opportunity to develop effective management strategies for aquatic resources. Where they are impaired, developing proper restoration and/or recovery management strategies for these streams is hindered by the lack of information regarding their biological and ecological characteristics. While a considerable amount of information is available about ecological conditions in New River, very little is known about the components, and their interactions, of the numerous streams tributary to the New River.

The West Virginia Department of Natural Resources stock several of these streams with trout. At present we do not have sufficient information about the status of aquatic populations and communities in these streams to accurately, or adequately, evaluate the impact of trout stocking. Also, these streams may serve as refugia for rare species, and others that have suffered population declines from natural or anthropogenic causes.

Completion of this effort will allow the National Park Service to more intelligently meet its obligations, as specified in the enabling legislation for New River Gorge National River, to consult with the State of West Virginia regarding fish and wildlife management within the park. Our current knowledge of these streams does not permit this. Also, completion of this effort will allow the National Park Service to determine the presence of, and develop proper management strategies for, any aquatic species of habitats of special concern. Finally, completion of this effort will serve as the basis for developing future monitoring efforts for these streams.

Description of Recommended Project or Activity

The objective of this effort is to provide a systematic survey of aquatic ecological conditions in the park of streams tributary to New River Gorge National River. This information will provide a comparable picture of "now" conditions in each of these streams, as serve as a reference point for future monitoring efforts. This information will also provide a baseline to guide management of activities in the watersheds of these streams.

This project is envisioned as a two-phase, 3-year effort. In the first phase, streams and watersheds will be mapped in the park's GIS system. This will allow the linking of future data collection efforts to watershed characteristics. The first part of this linking will be the incorporation of existing information, primarily periphyton and fishes, into the GIS database. It is expected that this phase will take one year to complete.

The second phase will occur over two years. During the first year baseline data will be collected on one half of the tributaries. This information will include one-time samples of fishes, benthic macroinvertebrates, and periphyton. Fishes will be sampled by three-pass electrofishing with a backpack electroshocker. Invertebrates will be sampled according to RBP II protocols in cobble-pebble habitat (and possibly on bedrock-boulder). Periphyton from cobbles and bedrock-boulders will be collected by scraping. During the second year of this phase, streams not sampled during the first year will be sampled.

Fish will be identified to species, weighed and measured, and returned to the stream. Preserved invertebrate samples will be returned to the lab for subsampling. From the subsamples, individuals will be identified to the lowest reasonable taxon (e.g. genus for most taxa, subfamily for Chironomidae). Preserved periphyton samples will be returned to the lab where they will be identified to the lowest reasonable taxon, probably genus, and enumerated. Standard metrics will be calculated and be the basis for data analysis.

Proposed Budget

Preliminary estimates are that this project will cost $45,000 during the first year, and $40,000 during each of the second and third years, for a total of $135,000. More detailed budget estimates will be developed at a later date.

Outreach to Anglers on the Effects of Bait-Bucket Fish Introductions

RMP Project Number: NERI-N-001.124
PMIS Number: 91440

Background

The New River system has only 46 native fishes and the lowest ratio of native fishes to drainage area of any river system in the eastern United States. The New River fish fauna is generally characterized as depauperate, and having unfilled niches. The fish fauna of the New River system has been extremely susceptible to invasion, and is not presently in a state of equilibrium. In a comprehensive review (Jenkins and Burkhead 1994) the New River system was listed as having the largest number and proportion (42 of 89) of introduced freshwater species of all major eastern and central North American drainages.

New River Gorge National River contains one of the most important warm-water fisheries in West Virginia. The introduction to the New River and its tributaries of new species of fish continues at the present (Cincotta *et al*. 1999). Several endemic species are at risk of competitive exclusion from the non-natives. Fish species including the telescope shiner (*Notropis telescopus*), spottail shiner (*Notropis hudsonius*), margined madtom (*Noturus insignis*), least brook lamprey (*Lampetra aepyptera*), and variegate darter (*Etheostoma variatum*) are expanding their ranges in the New River system. Most of the fish species that are expanding their ranges are popular baitfish, and it is probable that most of the introductions result from anglers releasing unused bait into streams.

Once a fish has been introduced to the system, its range may expand either because of further bait-bucket introduction, or because it out-competes native fish for available resources. It is likely that many anglers are unaware that fish distribution varies significantly among different streams in the same area, or that moving fish can result in adverse effects to the fish already present in a favorite river. An outreach program to educate anglers about these and other fisheries management concerns is one of the few options with the potential to effectively reduce bait-bucket introduction of fish.

Description of Recommended Project or Activity

Interpretive materials including signs and posters will be developed which explain the unique nature of the New River system fish assemblage, and the risk that invasive, non-native fish pose to native fish, particularly endemic species. These materials will be displayed at bait shops and popular fishing access points. The possibility of producing public service announcements, in cooperation with the West Virginia Department of Wildlife Resources and the U. S. Fish and Wildlife Service, will also be explored.

Literature Cited

Cincotta, D., D. Chambers and T. Messinger. 1999. Recent changes in the distribution of fish species in the New River Basin in West Virginia and Virginia. Pages 98 – 106 *in* Proceedings of the New River Symposium, Boone, N.C., April 16, 1999. National Park Service, Glen Jean, WV.

Jenkins, R. and N. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD. 1079 pp.

Proposed Budget

Preliminary estimates are that this project will cost $15,000. More detailed cost estimates will be developed at a later date.

Determine Status and Trends of New River Crayfish Community

RMP Project Number: NERI-N-001.112
PMIS Number: 60838

Background

Six species of crayfish have been described from New River Gorge National River (National Park Service 1994). Jezerinac *et al*. (1995) list five species (*Orconectes sanbornii*, *O. virilis*, *O. spinosus*, *Cambarus bartonii carinirostris*, and *C. sciotensis*) that are widespread (to differing degrees) in the New River Gorge area. A sixth species (*O. obscurus*) has also been collected from the New River (Markham *et al*. 1980).

The two *Cambarus* species are considered native. *Orconectes virilis* was introduced to Bluestone Lake prior to 1972 (Edmundson 1974). By 1979 they comprised 90% of samples taken between Bluestone Dam and Sandstone Falls (Markham *et al*. 1980). It is likely that *O. sanbornii* were introduced later, as none were collected in 1979. By 1983-1985, they were the predominant crayfish in the 1.1km below Bluestone Dam (Roell and Orth 1992). Also, *O. obscurus* comprised 3% of the assemblage in 1979 (Markham *et al*. 1980), but were not collected in 1984 or 1985 (Roell and Orth 1992). Non-native crayfish were likely introduced to the New River by anglers as discarded or escaped bait (Miller 1997). Introduction of non-native crayfish into areas inhabited by native species (e.g. Hill and Lodge 1999), along with the restricted ranges of most crayfish, are major factors in about 50% of U.S. and Canadian crayfish being in need of conservation recognition (Taylor *et al*. 1996).

Several other crayfish have been collected near the parks. The West Virginia Natural Heritage Program (NHP) lists the New River crayfish (*Cambarus chasmodactylus*) as a species of special concern. Although Jezerinac *et al*. (1995) considered *C. chasmodactylus* restricted to the Greenbrier River (the largest New River tributary), this species has been reported from another major tributary, the Bluestone River (Hobbs 1989). *Cambarus longulus* is known from the New River in Virginia. Any West Virginia specimen would likely be a recent bait bucket introduction. *Cambarus veteranus*, also a NHP species of special concern, is known from the upper Bluestone River watershed. *Cambarus robustus* is common downstream from New River Gorge National River, although a disjunct population is known from the Greenbrier River above the park. *Cambarus necterius*, another NHP species of special concern, is endemic to the New River watershed, specifically the General Davis Spring cave system in the Greenbrier River basin.

Crayfish are a large part of a significant bait fishery in New River between Bluestone Dam and Sandstone Falls (Nielsen and Orth 1988). Annual harvest by anglers and commercial bait catchers was about five percent of annual production (Roell and Orth 1992). Overall crayfish production in New River between Bluestone Dam and Sandstone Falls was about 7.0 grams live weight per square meter per year (Roell and Orth 1992).

About half the production was by *C. sciotensis*, and the rest by *O. virilis* and *O. sanbornii*.

No surveys of crayfish have occurred within New River Gorge National River since 1985. Due to changes in community structure noted in earlier studies and the definite possibility of species introductions by anglers, it is imperative for the National Park Service to assess the status of the crayfish community, and to document any changes that have occurred in the last 15 years.

Description of Recommended Project or Activity

The objectives of this project are to assess the status of crayfish community and populations, and determine if negative trends noted in 1985 have continued.

These objectives will be accomplished by completing a systematic survey of New River crayfish communities. Crayfish will be sampled from the entire length of New River within New River Gorge National River. Animals collected will be identified, sexed, measured, and weighed. Except for individuals retained for voucher specimens and reference collections for park use, organisms will be returned to the river after sample processing. Population density, species richness and diversity, and community composition will be calculated. Population distributions will be mapped, and the new data will be compared to prior studies to document crayfish community changes. Color photographs will be made of both sexes of adults and juveniles of each species collected. Reference collections consisting of both sexes of adults and juveniles of each species collected will be prepared. Photographs and reference collections will assist future Resource Management efforts related to crayfish, and be the basis for Interpretive and educational materials about crayfish.

Literature Cited

Edmundson, J., Jr. 1974. Food habits, age and growth of flathead catfish, *Pylodictus olivaris* (Rafinesque) in Bluestone Reservoir, West Virginia. MS Thesis, West Virginia University, Morgantown.

Hill, A.and D. Lodge. 1999. Replacement of resident crayfishes by an exotic crayfish: the roles of competition and predation. Ecological Applications 9: 678-690.

Hobbs, H., Jr. 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). Smithsonian Contributions to Zoology 480, 236 pp.

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Miller, S. 1997. Crayfish, crawdads and crawcrabs - the lobsters in your backyard. West Virginia Nongame Wildlife & Natural Heritage News 14(4): 2.

National Park Service. 1994. Resource management plan 1994, New River Gorge National River, Gauley River National Recreation Area, Bluestone National Scenic River. National Park Service, Glen Jean, WV.

Nielsen, L. and D. Orth. 1988. The hellgrammite-crayfish bait fishery of the New River and its tributaries, West Virginia. North American Journal of Fisheries Management 8: 317-324.

Roell, M. and D. Orth. 1992. Production of three crayfish populations in the New River of West Virginia, USA. Hydrobiologia 228: 186-194.

Taylor, C., M. Warren, Jr., J. Fitzpatrick, Jr., H. Hobbs III, R. Jezerinac, W. Pflieger and H. Robinson. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21: 25-37.

<u>Proposed Budget</u>

Site selection reconnaissance; (GS 5-5 Technician), 40 Hours @ $18.39/hour	$735.60
Site selection reconnaissance; (GS 12-5 PI), 40 Hours @ $40.42/hour	$1,616.80
Field sampling; (GS 5-5 Technician), 20 sites at 5 hours/site = 100 Hours @ $18.39/hour	$1,839.00
Field Sampling; (GS 12-5 PI), 20 sites at 5 hours/site = 100 Hours @ $40.42/hour	$4,042.00
Laboratory processing; (GS 5-5 Technician), 120 Hours @ $18.39/hour	$2,206.80
Laboratory processing oversight; (GS 12-5 PI), 40 Hours @ $40.42/hour	$1,616.80
Data Entry; (GS 5-5 Technician), 80 Hours @ $18.39/hour	$1,471.20
Map Production; (GS 12-5 GIS Specialist), 80 Hours @ $40.42/hour	$3,233.60
Reference collection; (GS 5-5 Technician), 80 Hours @ $18.39/hour	$1,471.20
Reference collection; (GS 12-5 PI), 40 Hours @ $40.42/hour	$1,616.80
Statistical data analysis; (GS 12-5 PI), 120 Hours @ $40.42/hour	$4,850.40
Report preparation; (GS 12-5 PI), 80 Hours @ $40.42/hour	$3,233.60

Supplies: traps (8x$15=$120), nets (2x$300=$600), buckets (8x$10=$80), chemicals ($400), jars ($200), office supplies ($300), miscellaneous ($500)	$2,200.00
Vehicle rental; GSA class G61 Jeep Cherokee for two months @ $278.50/month	$557.00
Vehicle mileage: GSA mileage charges for above vehicle, 2000 Miles @ $0.16/mile	$320.00
Per diem; Two people (PI and Technician) for 10 days/nights each (total 20 days) @ $85.00/day ($55 lodging, $35 M&IE)	$1,700.00
TOTAL	**$32,710.80**

Determine Status and Trends of New River Mussel Community

RMP Project Number: NERI-N-001.105
PMIS Number: 1375

Background

Approximately one third of the North American mussel fauna is threatened or endangered, and the decline of mussel communities is well documented. By filtering water to feed on suspended particles, mussels play an important role in maintaining water clarity and quality. Protection and monitoring of mussels are especially important to help identify and understand long term mechanisms for environmental change. No survey of mussels has been performed in New River Gorge National River since 1984-85. Given the declining status of mussel communities across North America, it is imperative that another survey be completed to assess the trends in populations of New River mussels.

New River Gorge National River supports a low-diversity mussel fauna. The low diversity within the Park, and in the New River as a whole, is notable when compared with the downstream Kanawha River, formed by the confluence of the New and Gauley rivers. Seven species of live mussels (Unionidae), and shells of an eighth, were collected in NERI during 1984-85 (Jirka and Neves 1987). Thirty-four species, including the federally endangered pink mucket pearly mussel (*Lampsilis orbiculata*), have been described from the Kanawha River. Some of the same barriers that prevent fish migration and have led to a depauperate native fish community in the New River, particularly Kanawha Falls, may prevent mussel migration and have led to the low diversity mussel community present in New River Gorge National River. Since most mussels require specific fish hosts to complete their life cycle (Pennak 1989), the depauperate New River native fish community may contribute to the depauperate mussel community.

In the 1984-85 survey, mussels were much more common towards the upstream end of the park, decreasing significantly below Glade Creek. No living or dead mussels were found in the lower eight miles of river within the park. Habitat availability appears to limit establishment of mussel beds in these lower reaches, and probably leads to the relative scarcity of beds below Glade Creek. Mussel beds are susceptible to a variety of potentially damaging environmental impacts, including physical habitat disturbance, extremes in flows and water quality degradation. Illegal harvesting of mussels has become popular in the Mid-Atlantic States because of high commercial value. An illegal commercial harvest was documented for New River in 1993.

The mucket (*Actinonaias carinata*) was by far the most common species found in 1984-85. It composed over 90% of the individuals collected, and occurred in all areas that mussels were found. Purple wartyback (*Cyclonaias tuberculata*) and spike (*Elliptio dilatata*) were the next two most common species, comprising about four and two percent, respectively, of the fauna. These two species were also present in all mussel beds. Buckhorn, or pistol grip, (*Tritogonia verrucosa*) were relatively common (<2% of the fauna) above Sandstone Falls, but much less common below this point. Elktoe (*Alasmidonta marginata*), wavy-rayed lampmussel, (*Lampsilis fasciola*), and pocketbook (*L. ovata*) were collected in very small numbers. Shells of wavy-rayed fasciola and pocketbook were collected in many mussel beds where no live individuals of these species were found. Shells of green floater (*Lasmigona subviridis*) were also collected during the survey.

Several other mussels have been collected or reported from the New River Gorge area. Empty valves of *Pygandon* (=*Anodonta*) *grandis* have been found immediately below Bluestone Dam and near the lower end of Brooks Falls (Jirka and Neves 1987). The lilliput (*Toxolasma parvus*) has been collected in the lower New River only near the mouth of the Gauley River (Jirka and Neves 1987). A single specimen of rainbow (*Villosa iris iris*) has been reported from Bluestone River (Tolin 1985), a tributary to New River just above New River Gorge National River. Another species, mapleleaf (*Quadrula quadrula*), has been reported from New River at Sandstone Falls, but this report was questionable because no other record exists for this species for the entire New River drainage (Jirka and Neves 1987). A single specimen of mapleleaf was positively identified from the Stonecliff area in 2002. The West Virginia Natural Heritage Program (NHP) lists all native Unionidae as species of special concern. Many of the species found in New River are also listed by other states' NHPs.

New River Gorge National River populations of several of these mussel species are important for the species as a whole (Richard Neves, Virginia Polytechnic and State University, personal communication 2002). New River Gorge National River has the best populations of mucket and purple wartyback remaining in the Ohio River Basin. Even though they are not listed, the New River populations are strongholds for these species. Thus they are important for survival of these species throughout their range. Buckhorn is declining throughout its range. The New River Gorge National River population, if it is reproducing, is important for this species. Green floater has been proposed as a federal species of concern. The genetics of the Interior Basin populations of this species are different from the Atlantic Coast populations, and they may be distinct subspecies. Elktoe are nearly extinct from New River in Virginia. This species is also a contender for federal protection.

An exotic mollusk, the Asiatic clam (*Corbicula fluminea*), has been well established in New River since at least 1975. Population numbers, biomass, and production of this organism probably greatly exceed those of all native mussels. Unlike Unionidae, *Corbicula* sp. do not require a specific fish host to complete their life cycle (Pennak 1989). Another invasive exotic, the zebra mussel (*Dreissena polymorpha*) has not been reported in the New River as of 1998 (U. S. Geological Survey 1999). However, zebra mussels are well established in the Kanawha River (about 10 miles below the downstream end of the park) and could easily be introduced to heavily boated Bluestone Lake (immediately above the upstream end of the park) at any time.

Several projects in or near New River Gorge National River will require evaluation of existing mussel communities and the potential impact of these projects on those communities. The opportunity exists to piggy-back these projects to combine funding such that a much needed comprehensive survey of mussels is produced. Agencies that may be partners in a greater project include the U. S. Army Corps of Engineers, U. S. Fish and Wildlife Service (FWS), West Virginia Division of Natural Resources (DNR), West Virginia Division of Environmental Protection (DEP), West Virginia Division of Highways (DOH), and Tri-Cities Power.

One of these projects is a proposed addition of hydropower capability to Bluestone Dam, just upstream of the park boundary. This project is a cooperative venture between the Corps of Engineeers and Tri-Cities Power, which includes the City of Hinton, an important park neighbor. The West Virginia DOH is proposing to rehabilitate two bridges across New River. This rehabilitation may involve instream work, and impacts to mussels are a big concern. One of these bridges is at Hinton, and the other is at Stonecliff, within the park boundary. In addition to the National Park Service (NPS), the FWS, DNR and DEP have expressed interest in these projects. Initial work on the Hinton bridge was stopped last year after NPS, FWS, and DEP objected to this work being started without proper permits. One result of this action was that DOH was fined $1,000,000 by DEP. Some of this money is available for mitigation, which may include mussel surveys near these bridges.

Description of Recommended Project or Activity

The objectives of this project are to document the status and trends of freshwater mussel populations within New River Gorge National River, and to determine if the invasive alien zebra mussel or the endangered pink mucket (reported downstream of the park) occurs within the park.

The objectives will be met by a systematic survey of New River mussels. Mussel beds within New River Gorge National River will be mapped. Comparison with the 1984-5 survey will document trends in the mussel beds. Location and extent of beds, bed habitat and hydraulic characteristics will be documented in a GIS-compatible map product. Representative mussel beds will be sampled for species composition and density. Comparison of this data with earlier data will document trends in the mussel community. Special effort will be made to determine if the pink mucket or zebra mussel are present in the park

High quality color photographs will be taken of the various sizes of each species found. Reference collections of shells, and the photographs, will be provided to the National Park Service. These collections and photographs will be used by both Resource Management and Interpretation and Visitor Services staff members.

Literature Cited

Jirka, K. and R. Neves. 1987. A biological survey of the New River Gorge National River, Volume 4, A survey of freshwater mussels. Virginia Polytechnic Institute and State University, Blacksburg, VA. Unpublished report on file at National Park Service headquarters, Glen Jean, WV. 55 pp.

Pennak, R. 1989. Freshwater invertebrates of the United States, 2nd ed. Wiley, New York. 803 pp.

Tolin, W. 1985. Survey of the freshwater mussels of the New River (Wylie Islands to Bluestone Lake), lower Bluestone River, and lower Inidan Creek, Summers County, West Virginia. Proceedings of the 4th Annual New River Symposium: 19-26.

U. S. Geological Survey. 1999. Water resources data West Virginia water year 1998. Water-Data Report WV-98-1, 476 pp.

Proposed Budget

Vehicle rental; GSA class G61 Jeep Cherokee, four months @ $278.50/month	$1,114.00
Vehicle mileage; GSA charge for above vehicle, 4000 Miles @ $0.16/mile	$640.00
Supplies; Office supplies ($200), buckets (20 x $10 = $200), chemicals ($300), expendable supplies ($400), misc. supplies ($400)	$1,500.00
Per diem; Lodging ($55/day) and M&IE ($35/day) for 10 days each for PI and 2 Techs, 30 days @ $85.00/day	$2,550.00
Boat rental; outboard motorboat for 4 days x 8 hours/day x $40/hour	$1,280.00
Site selection reconnaissance; (GS 12-5 PI), 40 Hours @ $40.42/hour	$1,616.80
Site selection reconnaissance; (Two GS 5-5 Technicians), 2x40 hrs each = 80 Hours @ $18.39/hour	$1,471.20
Field sampling; (GS 5-5 Technicians), 40 sites at 2 hours/site X 2 technicians = 160 Hours @ $18.39/hour	$2,942.40
Field sampling supervision; (GS 12-5 PI), 160 Hours @ $40.42/hour	$6,467.20
Laboratory processing; (GS 5-5 Technicians), 200 Hours @ $18.39/hour	$3,678.00
Laboratory processing oversight; (GS 12-5 PI), 40 Hours @ $40.42/hour	$1,616.80
Data entry; (GS 5-5 Technician), 80 Hours @ $18.39/hour	$1,471.20
Statistical data analysis; (GS 12-5 PI), 80 Hours @ $40.42/hour	$3,233.60
Map production; (GS 12-5 GIS Specialist), 80 Hours @ $40.42/hour	$3,233.60
Report preparation; (GS 12-5 PI), 80 Hours @ $40.42/hour	$3,233.60
Reference collection: (GS 12-5 PI), 80 Hours @ $40.42/hour	$3,233.60
TOTAL	**$39,282.00**

Note: This project was awarded funding ($39,300) in FY03 by the National Park Service Biological Resource Management Division.

Determine Baseline Conditions for Wolf Creek AMD Treatment

RMP Project Number: NERI-N-001.110
PMIS Number: 53197

Background

Wolf Creek is one of the most visible tributaries to New River within New River Gorge National River. Wolf Creek enters New River at Fayette Station, the most heavily used take-out for over 200,000 whitewater boaters each year. Wolf Creek also is crossed by three park trails. The waters and biota of Wolf Creek are part of the "outstanding natural" resources that the National Park Service is charged with conserving in the enabling legislation for New River Gorge National River.

Originating just outside Oak Hill, Wolf Creek flows through Oak Hill and Fayetteville, the two largest towns in Fayette County, and is a major portion of the water supply for Fayetteville. Formerly stocked with trout by the state, Wolf Creek has suffered serious detrimental impacts from acid mine drainage (AMD). Water immediately downstream from a coal gob pile often exhibits a pH of less than 3. Pre-gob pile aquatic life in Wolf Creek was killed, and Fayetteville was forced to find a new water supply. An earlier attempt to remedy this problem failed. The recent settlement of a legal proceeding makes $375,000, under joint trusteeship of the West Virginia Department of Environmental Protection and Plateau Action Network (PAN, a local watershed group) available to treat the gob pile.

To properly evaluate the potential positive impacts of proposed reclamation, a more thorough description of existing conditions is required. This activity will provide this description.

Description of Recommended Project or Activity

The objective of this project is to determine the baseline conditions of physical, chemical, and biological parameters in Wolf Creek, and to monitor the effectiveness of reclamation of a site of acid mine drainage input on water quality. After the initial implementation of this project, NERI will assume the continuous monitoring of Wolf Creek as part of its basic water quality monitoring program.

Two sampling locations will be established on Wolf Creek within New River Gorge National River (NERI). One site will be upstream of a large mine water discharge, and the other will be downstream at a site presently used for water quality monitoring. Quarterly evaluations will be made for one year of existing aquatic biological communities and basic water quality. Where possible, NAWQA protocols will be followed.

Fish populations will be estimated with two-pass electrofishing. All fish will be identified, weighed, and measured. Benthic macroinvertebrates will be sampled (n=5) using an Ellis-Rutter Stream Sampler (formerly the Portable Invertebrate Box Sampler, or PIBS). Samples will be preserved in the field and returned to the lab for identification and counting. Algal biomass and chlorophyll a will be measured from 10 bar-clamp samples returned to the lab for analysis. A variety of community metrics will be determined to help interpret the biological data. Water quality measurements made during biological sampling events will be supplemented with continuous records from a Hydrolab MiniSonde to be deployed at the lower site, and additional temperature probes (e.g. HOBO) deployed at the upper site.

<u>Proposed Budget</u>

Vehicles		
	Vehicle rental	$557.00
	Vehicle mileage	$320.00
Equipment and Materials		
	Temperature Probes	$700.00
	Installation Materials	$300.00
	Continuous Sampler	$6,000.00
	pH meter	$1,100.00
	Field Supplies	$1,100.00
	Laboratory Supplies	$1,000.00
Labor		
	Installation Labor (WG-10)	$992.00
	Monitoring (Tech)	$2,942.40
	Monitoring (PI) Biologist	$2,697.60
	Data Analysis (Tech)	$1,471.20
	Data Analysis (PI)	$2,697.60
	Report Preparation (Tech)	$1,471.20
	Report Preparation (PI)	$2,697.60
TOTAL		**$26,046.60**

Determine Partitioning of Polycyclic Aromatic Hydrocarbons in Streams of the New River Watershed

RMP Project Number: NERI-N-001.106
PMIS Number: 75053

Background

Streams draining Appalachian coal-mining areas contain higher concentrations of polycylic aromatic hydrocarbons (PAH's) in streambed sediments than do streams representing any other rural land use in the United States. PAH's present a significant threat to wildlife; they have been shown to cause many adverse effects, both lethal and sublethal, on a variety of aquatic organisms (Eisler 2000), including liver tumors in bottom feeding fish (Baumann *et al*. 1991). Unpublished statistical analysis showed that PAH's were weakly but positively correlated with external fish anomalies at Kanawha River Basin NAWQA (U. S. Geological Survey's National Water Quality Assessment Program) fixed sites. Concentrations of many PAH's in streams draining mined basins exceeded Environment Canada's Probable Effects Level for the protection of aquatic life, including two of the six sediment samples collected in or near the New River Gorge National River area. The two highest total PAH concentration (as the sum of individual compounds) from about 40 bottom sediment samples collected by NAWQA in the Kanawha River Basin were from Peters Creek, a tributary of the Gauley River (about 13,000 μg/kg), and the Bluestone River (about 8,800 μg/kg). Both streams were sampled a short distance upstream from National Park Service boundaries for Gauley River National Recreation Area and Bluestone National Scenic River, respectively.

PAH's are hydrophobic and tend to accumulate in streambed sediment. They are rapidly metabolized rather than accumulated by fish, although they are accumulated in some invertebrates. PAH's are commonly found in the environment as products of combustion. Much of the PAH's in streambed sediment in the Kanawha River Basin is contained in sand- and finer-sized coal particles; three coal samples from the region contained between 20 and 85 percent PAH's by weight. However, questions have been raised concerning the bioavailability of PAH's in particulate coal. More information is needed on PAH's in streams of the New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River to determine how severe a threat they represent to aquatic life.

The objectives of this study are to determine how severe a threat PAH's pose to aquatic life in streams of the New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River. This will be accomplished by determining (1) if PAH's are bioavailable in these streams influenced by coal mining and related activities, and (2) the relation of the bioavailable fraction of PAH's to the concentration of PAH's in streambed sediment.

Description of Recommended Project or Activity

PAH's will be measured in streambed sediment and in semipermeable membrane devices (SPMD's, surrogates for biota) to determine how they partition in the aquatic system and if they are bioavailable. These samples will be collected at five sites in summer 2002.

Streambed sediment samples will be collected and analyzed for PAH's and total and organic carbon. Samples will be sieved on site, using a 2-mm sieve. Streambed sediment size distribution will be determined by measuring the intermediate axis of 100 particles along three transects within the sampling reach. A detection limit of about 5 μg/kg in streambed sediment will be possible for PAH's.

Semipermeable membrane devices will be used to directly measure the bioavailability of PAH's. SPMD's are dialysis tubes filled with purified fish lipids, and can take up a wide variety of hydrophobic organic compounds in aquatic systems. SPMD's will be deployed for one month at five sites during low flows. Sites will be selected through consultation between the U. S. Geological Survey project chief and the New River Gorge National River Aquatic Resources Team Leader. Three replicate SPMD's will be deployed at each site, and retrieved after one, two, and four weeks exposure. A trip blank will be used for each site visit to determine if the SPMD's were exposed to any PAH's during their handling. Stream temperature will be monitored hourly while the SPMD's are deployed. SPMD's will be deployed in a perforated stainless steel canister, to minimize the exposure of the SPMD's to light; light is undesirable both because it can photodegrade some PAH's, and also because it contributes to periphyton growth on the deployed SPMD. Water samples will be collected to determine total and dissolved organic carbon and total ion concentrations at each of the sites. Water and sediment samples will be collected when SPMD's are retrieved. Samples will be analyzed at the U. S. Geological Survey National Water Quality Laboratory. The National Park Service will provide fish community and anomaly analysis at each site.

Data will be published and interpreted in a U. S. Geological Survey Water-Resources Investigation Report by October 1, 2003.

This study supports Federal efforts to improve water quality and stream ecosystems in degraded watersheds in National Park Service lands. It contributes to high-priority goals of the U. S. Geological Survey by helping determine effects of land use practices on streams, helping understand relations between water quality and stream ecosystem health, and better quantifying effects of active and abandoned mines, and mining-related activities, on streams.

This study will help staff of New River Gorge National River determine the threat PAH's pose to park aquatic biological resources. The findings of this study will help guide National Park Service management response to activities, ongoing and proposed, within and external to park boundaries. This study will also provide information on the bioavailability of PAH's in an area where streambed sediment PAH's are probably dominated by coal. These results will be transferable to other coal-mining regions.

Literature Cited

Baumann, P., M. Mac, S. Smith and J. Harshbarger. 1991, Tumor frequencies in walleye (*Stizostedion vitreum*) and brown bullhead (*Ictalurus nebulosus*) and sediment contaminants in tributaries of the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 48: 1804-1810.

Eisler, R. 2000. Handbook of chemical risk assessment—health hazards to humans, plants, and animals, volume 2, organics. Lewis Publishers, Boca Raton, FL, 792 pp.

Proposed Budget

Estimates developed by the U. S. Geological Survey are that this project will cost $55,400 over two years. This includes the following personnel costs:

Project chief (GS-11)	436 hours
Field helper (GS-6)	40 hours
Editor (GS-11)	16 hours
GIS specialist (GS-11)	8 hours

Note: In FY2002 the National Park Service Northeast Region awarded this project funding in the amount of $42,500. This funding will be spent in 2002 and 2003. The U. S. Geological Survey will provide the balance of $12,900.

Assess Riparian Conditions in New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area

RPM Project Number: NERI-N-001.125
PMIS Number: 91445

Background

The maintenance of healthy riparian systems is essential in obtaining and sustaining biologically diverse ecosystems. Healthy riparian systems are geologically stable, with stream flow and sediment discharges in dynamic equilibrium with their upland watersheds. The systems' wetland and riparian vegetation has appropriate structural, age, and species diversity. When these attributes are maintained, riparian systems provide forage and cover for wildlife and improve water quality by filtering sediment and recycling nutrients. If, however, any of the essential attributes are missing or degraded, or if the system becomes geologically unstable, widespread erosion may occur that will degrade water quality and cause damage or loss of wetland and riparian habitats.

A riparian-wetland assessment tool, The Process for Assessing Proper Functioning Condition (Prichard *et al.* 1998), has been used in the western United States to evaluate riparian systems by the U. S. Bureau of Land Management. The U. S. Forest Service and the Natural Resources Conservation Service are now applying this riparian assessment method. This technique uses an interdisciplinary team to assess riparian area "functionality" according to 17 hydrologic, vegetation, and stream geomorphologic factors such as erosion, deposition, and channel geometry. It provides an initial screening that can separate areas that are functioning well from those in need of more intensive evaluation or management actions. In this way, money and effort can be targeted toward the higher priority issues.

The "functioning condition" of a riparian area refers to the stability of the physical system, which is dictated by the interaction of geology, soil, water, and vegetation. In a healthy system, the channel adjusts in slope and form to handle larger runoff events with limited perturbation of the channel and associated riparian-wetland plant communities.

Evaluation of the functioning condition is not simply an assessment of the ecological status or serial stage of the vegetation community. Rather, evaluation is based upon the concept that the basic elements of physical habitat must first be in place and functioning properly before management of such things as potential natural vegetation communities can occur. At first glance, most of the riparian zones in Bluestone National Scenic River, New River Gorge National River, and Gauley River National Recreation Area appear to be stable and functioning properly. However, this qualitative assessment has not been documented or quantified. To provide appropriate recommendations for the management of the parks' streams and riparian areas, a two-year project is recommended that will assess riparian functionality.

Description of Recommended Project or Activity

The basic goal of this project is to use the Bureau of Land Management's Process for Assessing Proper Functioning Condition (PFC) to classify park streams as "proper functioning," "functional at-risk," or "nonfunctional." This goal can be met by implementing a coordinated review of existing literature and tactical field investigations.

Riparian Functionality Assessment

In accordance with the Bureau of Land Management's protocols for assessing riparian functionality, an interdisciplinary team with expertise in hydrology, soil science, geology, and riparian vegetation will evaluate the capability and potential of park streams by using existing literature and field examinations to obtain information including:

- identification and description of relic areas;
- review of historical photos, survey notes, and other documents that indicate historic condition;
- review of floral and faunal species lists;
- determination of species habitat needs related to species that are or were present;
- examination of soils to determine if they were saturated at one time and are now well drained;
- estimation of frequency and duration of flooding on floodplains and terraces, particularly in the New and Gauley rivers which are downstream from dams;
- identification of current vegetation and determination of that species' historical occurrence in the area;
- determination of the entire watershed's general condition and identification of its major landforms; and,
- identification of limiting factors, both human-induced and natural, and determination of needed remedial actions.

Proper Functioning Condition

Stream/riparian areas are functioning properly when adequate vegetation, landform, or large woody debris are present to:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bed load, and aid floodplain development;
- improve floodwater retention and ground water recharge;
- develop root masses that stabilize stream banks against cutting action;
- develop diverse ponding and channel characteristics to provide habitat and the water depths, duration, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and,
- support greater biodiversity.

Functional-at-Risk

Stream/riparian areas are currently in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly functioning system, but may be poised to suffer severe erosion during a large storm due to likely migration of a headcut or increased runoff associated with the disturbance in the watershed caused by the storm.

Nonfunctional

Stream/riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, or providing forage and cover for wildlife and livestock. The absence of certain physical attributes, such as a floodplain where one should exist, is an indication of nonfunctioning conditions.

The product of this phase of the project will be a report containing a compendium of the standard checklist for each riparian area evaluated by the team and a brief summary describing the team's conclusions regarding the overall condition of the park's riparian areas.

Literature Cited

Prichard, D., J. Anderson, C. Correll, J. Fogg, K. Gebhardt, R. Krapf, S. Leonard, B. Mitchell and J. Staats. 1998. Riparian area management – a user guide to assessing proper functioning condition and the supporting science for lotic areas. U. S. Bureau of Land Management, Tech. Ref. 1737-15, Denver, CO.

Proposed Budget

Based on work in another park of similar size (Theodore Roosevelt National Park), preliminary estimates are that this project will cost about $45,000. More detailed cost estimates will be developed at a later date.

Investigate Effects of River Regulation on Rare Plant Communities

RMP Project Number: NERI-N-001.126
PMIS Number: 91446

Background

Unique plant assemblages called the Appalachian River Flatrock communities are limited in West Virginia to the New River Gorge (Rouse and McDonald 1986). Appalachian River Flatrock communities are defined by the presence of several species of regionally rare sedges, reeds, and grasses. These communities are found in large, horizontal riverside exposures of resistant sandstone, which were presumably produced by long-term scouring. Surveys of similar rock outcrops on the nearby Gauley, Meadow, and Greenbrier rivers did not identify the kind or diversity of rare plant species found in the New River Gorge. Three of five Appalachian River Flatrock sites known in West Virginia occur in the New River Gorge National River, and the other two are found a short distance downstream at Cotton Hill and Gauley Junction. Presumably, these communities are established in a riparian zone because they require occasional inundation, possibly to eliminate competitors. No information appears to be available regarding frequency of inundation of these riparian communities during the period before river regulation, when they were becoming established, or at present.

Description of Recommended Project or Activity

Estimates will be made of flood discharges and frequencies that presumably inundated the Appalachian River Flatrock communities before the New River was regulated. Measurements of stream-channel geomorphology at the sites of these communities would enable computer simulations of water surface elevation at a given flow, and thus, a means for determining historic frequency of inundation of the plant communities. The relation between current and historic frequency of inundation of these communities would provide insight into the likelihood that they will survive.

The U. S. Geological Survey stream gaging station Kanawha River at Kanawha Falls, just downstream from the confluence of the New and Gauley Rivers, has maintained a continuous stream-discharge record since 1876 (Ward *et al*. 1998). Flow of the Kanawha River was unregulated prior to 1939, when Claytor Dam was constructed. Construction of Bluestone Dam (1949) has increased the regulated drainage of the New River. Discharge records from Kanawha Falls, in addition to records from Gauley River near Belva (established 1929) and New River at Glen Lyn (established 1927) can provide a basis for estimating the flood frequency and discharge. Pre-regulation discharges for the two-, ten-, fifty-, and one hundred-year floods will be estimated for the New River downstream from the mouth of the Greenbrier River. These discharges are not likely to increase significantly between the upstream and downstream ends of the New River Gorge National River, a reach in which the drainage area only increases ten percent, from 6,256 square miles to 6,876 square miles. Flood frequencies for the current river regulation regime will be calculated for the New River at Thurmond.

The other component of the study will be mapping and geomorphic and hydraulic analysis of channel reaches including the three locations of the flatrock communities inside park boundaries. Channel geometry and slope will be mapped in sufficient detail to determine the river's discharge according to indirect methods (Benson and Dalrymple 1967). However, instead of determining the discharge from high-water marks, the water-surface elevation for both unregulated and regulated flood discharges will be back-calculated from each of the four target discharges at each of the three reaches. The location of the flatrock communities will then be mapped relative to the water-surface elevations of the target discharges. Mapping the channel of the New River will require a large, experienced crew with a total station surveying instrument, and a boat to complete the mid-channel depth profiling. Fieldwork will be done in October, at low flows, after which a report will be prepared describing the findings of the study.

Literature Cited

Benson, M. and T. Dalrymple. 1967. General field and office procedures for indirect discharge measurements. U.S. Geological Survey Techniques of Water-Resources Investigations Book 3, Chapter A1, 30 pp.

Rouse, G. and B. McDonald. 1986. Rare vascular plant survey, New River Gorge National River. West Virginia Division of Natural Resources, Natural Heritage Program Final Report CA-4000-4-0012, Elkins, WV, 55 pp.

Ward, S., B. Taylor and G. Crosby. 1998. Water resources data, West Virginia, water year 1997. U. S. Geological Survey Water-Data Report WV-97-1, Charleston, WV, 392 pp.

Proposed Budget

Preliminary estimates developed by the U. S. Geological Survey are that this project will cost $85,000. More detailed cost estimates will be developed at a later date.

Determine Travel Time and Dispersion of a Conservative Solute for the Gauley River in Gauley River National Recreation Area

RMP Project Number: NERI-N-001.127
PMIS Number: 91447

Background

Knowledge of travel time and dispersion of a soluble contaminant in the reach of the Gauley River within the Gauley River National Recreation Area could assist river managers in maintaining river habitat and water quality. Should an accidental spill of a soluble contaminant occur, travel time and dispersion of the spill is essential information for determining the time of exposure and concentrations that may affect plants and animals along the river. Because of the proximity of Summersville Dam just upstream of this river reach, river regulation may assist in mitigation responses to an accidental spill in this part of the Gauley River. The potential for such a spill exists because of hazardous waste and toxic chemical transport by highway and rail across the river and along the riverbanks.

Description of Recommended Project or Activity

The study area will be the reach of the Gauley River from the mouth at Gauley Bridge, West Virginia, upstream to the U. S. Geological Survey gauging station on the Gauley River below Summersville Dam. This reach flows through the entire length of the Gauley River National Recreation Area. Dye-tracer (Rhodamine WT) techniques will be used to develop an understanding of travel time and dispersion characteristics of the Gauley River. The following relations will be developed to assist river managers in assessing the flow and solute-transport characteristics affecting the movement of a solute cloud in the Gauley River National Recreation Area:

1. Relation between travel time of the leading edge, peak concentration, and trailing edge of the dye cloud and discharge of the river;
2. Relation between time of passage of the dye cloud and travel time of the peak concentration;
3. Relation between peak concentration and travel time of the peak concentration.

Travel time and dispersion of a conservative solute will be determined for three steady-flow discharges, low flow (from 100 to 600 cfs), medium flow (from 600 to 1,500 cfs), and high flow (from 1,500 to 2,500 cfs). Dye will be injected at Summersville Dam. Water samples will be collected at the five following downstream locations:

U. S. Geological Survey stream flow-gauging station Gauley River below Summersville Dam,
Confluence of the Meadow River with Gauley River (collected by boat),
Railroad bridge over Gauley River at Peters Junction,

Railroad bridge over Gauley River at Belva, and
Railroad or U. S. Route 60 bridge over Gauley River at its mouth (confluence with New River).

Techniques for analyzing water samples for the occurrence of dye will follow those described by Wilson *et al*. (1986) and Kilpatrick and Wilson (1989). Analysis of the occurrence of dye will be used to develop relations:

1. between travel time of the leading edge, peak concentration, and trailing edge of the solute cloud and discharge of the river,
2. between time of passage of the solute cloud and travel time of the peak concentration, and
3. between peak concentration and travel time of the peak concentration.

This study will provide essential information for developing an understanding of the transport and dispersion of soluble contaminants in Gauley River National Recreation Area and for possibly mitigating an accidental spill of a soluble contaminant in the Gauley River National Recreation Area. This information would assist park personnel and river managers in the protection of the water resource, in protection of the health and safety of the resource users, and in the protection of the plant and animal habitats. Information from this study can provide data for the following future studies:

1. Developing regional solute-transport equations.
2. Developing flow and solute-transport models for non-conservative constituents (releases from Summersville Dam are used to augment dissolved-oxygen concentrations during periods of low discharges in the Kanawha River).
3. Assessing the downstream effects of using Summersville Dam for power generation. (Summersville Dam provides a possible source for augmenting energy needs during peak-usage hours).

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Kilpatrick, F. and J. Wilson, Jr. 1989. Measurement of time of travel in streams by dye tracing. U. S. Geological Survey Techniques of Water-Resources Investigations, book 3, chapter A9, 27 pp.

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<u>Proposed Budget</u>

Based on preliminary information provided by the U. S. Geological Survey, this project would require $200,000 over 2 years to complete. More detailed cost estimates will be developed at a later date.

Determine Wave Propagation for the Gauley River in Gauley River National Recreation Area

RMP Project Number: NERI-N-001.128
PMIS Number: 91451

Background

Knowledge of travel time and dispersion of a soluble contaminant in the reach of the Gauley River within the Gauley River National Recreation Area could assist river managers in maintaining river habitat and water quality. Should an accidental spill of a soluble contaminant occur, travel time and dispersion of the spill would be essential information for determining the time of exposure and concentrations that might affect plants and animals along the river. Because of the proximity of Summersville Dam just upstream of this river reach, river regulation may assist in mitigation responses to an accidental spill in this part of the Gauley River. Knowledge of wave propagation on the Gauley River could assist river managers by determining the elapsed time and the river location that a wave produced by river regulation overtakes a contaminant cloud. The potential for such a spill exists because of hazardous waste and toxic chemical transport by highway and rail across the river and along the riverbanks. Knowledge of wave propagation on the Gauley could also assist anglers and rafters in determining when changes in river conditions may affect their recreation.

Description of Recommended Project or Activity

The study area will be the reach of the Gauley River from the mouth at Gauley Bridge, West Virginia, upstream to the U.S. Geological Survey gauging station on the Gauley River below Summersville Dam. This reach flows through the entire length of the Gauley River National Recreation Area. Wave propagation on the Gauley River will be studied by use of continuous records of stage and discharge at the U.S. Geological stream flow-gauging stations Gauley River below Summersville Dam and Gauley River at Belva. Additionally, two temporary gages will be installed at the railroad bridge at Peters Junction and either the railroad bridge or U.S. Route 60 bridge at the confluence of New River to assist in studying wave propagation (approximately 1 year of stage records will be collected). Travel times of the leading edge of changes in discharge (or waves) will be measured between the gauged locations. The discharge prior to the occurrence of the wave (base discharge) will be the average discharge determined from the two U.S. Geological Survey stream flow-gauging stations. Relations between travel times of waves and stream distance for approximately 5 base discharges will be developed from the wave-propagation analysis (Wilson *et al*. 1986).

The study will provide essential information for developing an understanding of wave propagation in the Gauley River National Recreation Area and for possibly mitigating an accidental spill of a soluble contaminant in the Gauley River National Recreation Area. This information would assist park personnel and river managers in the protection of the water resource, in protection of the health and safety of the resource users, and in the protection of the plant and animal habitats. Information from this study can provide data for the following future studies:

1. Developing regional solute-transport equations;
2. Developing flow and solute-transport models for non-conservative constituents (releases from Summersville Dam are used to augment dissolved-oxygen concentrations during periods of low discharges in the Kanawha River);
3. Assessing the downstream effects of using Summersville Dam for power generation. (Summersville Dam provides a possible source for augmenting energy needs during peak-usage hours.)

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Wilson, J. Jr., E. Cobb and F. Kilpatrick. 1986. Fluorometric procedures for dye tracing. U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chapter A12, 34 pp.

Proposed Budget

Preliminary estimates based on information provided by the U. S. Geological Survey are that this project would require $100,000 over 2 years to complete. More detailed cost estimates will be developed at a later date.

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APPENDIX A

PEAK DISCHARGE ESTIMATING EQUATIONS.

[A, drainage area in square miles; ----, indicates no value]

Recurrence interval, in years	Estimating equation	Drainage area break point, in square miles	Estimating equation
2	$85 A^{0.830}$	----	----
25	$282 A^{0.748}$	485	$203 A^{0.801}$
100	$437 A^{0.719}$	530	$303 A^{0.777}$

The drainage area break point is the drainage area for which the equation to the left is applicable when drainage areas are less than or equal to the indicated value; the equation to the right is applicable when drainage areas are greater than or equal to the indicated value. The 2-year equation is applicable throughout the range of drainage area.

The following examples illustrate the use of the table: a watershed with an area of 30 square miles would have a 25-year peak discharge of $282(30)^{0.748}$ = 3,590 cubic feet per second, while a watershed with an area of 500 square miles would have a 25-year peak discharge of $203(500)^{0.801}$ = 29,500 cubic feet per second.

APPENDIX B

Equations for the 7-day, 2-year and 7-day, 10-year low flows are represented below:

$$M7,2 = 0.0043\,A^{1.11}\,V^{-3.45}$$
$$M7,10 = 0.0002\,A^{1.18}\,V^{-5.76}$$

Where M7, 2 indicates the 7-day 2-year low flow in cubic feet per second;
M7, 10 indicates the 7-day 10-year low flow in cubic feet per second;
A is the drainage area in square miles; and,
V is the streamflow-variability index.

The following examples illustrate the use of these equations: a watershed with an area of 7.54 square miles and a stream-variability index of 0.45 as determined from figure in pocket would have a 7-day 2-year low flow of $0.0043(7.54)^{1.11}(0.45)^{-3.45} = 0.64$ cubic feet per second and a 7-day 10-year low flow of $0.0002(7.54)^{1.18}(0.45)^{-5.76} = 0.22$ cubic feet per second.